The Water Supply, Sewerage and Plumbing of Modern City Buildings

BY

WM. PAUL GERHARD, C.E.

MEM. AM. SOC. MECH. ENGINEERS

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PREFACE.

THIS book is the outgrowth of various lectures on "THE WATER SUPPLY OF BUILDINGS" and on "PLUMBING," which the author was requested to prepare for engineering societies, and also of some essays written for technical journals. These articles and lectures have been put in a revised and enlarged form, new illustrations and many diagrams and tables have been added, and thus the entire subject-matter has been brought up to date.

The book deals with the subject from a practical standpoint, being written by a practicing engineer, who has devoted many years to the special engineering topics under consideration.

The chapters while correlated to each other, are *purposely* so written that each one is complete in itself, and may be read or studied without reference to the others. While this necessarily involves some slight repetitions, the author nevertheless adopted this form because it seemed to him to have certain merits and advantages.

Chapter I presents in an elementary form the **Essentials of the Sanitary and Hydraulic Work, as applied to Modern Buildings,** chiefly those in cities.

Sanitary Fixtures and Appliances are discussed in Chapter II, which is freely illustrated by numerous cuts of up-to-date sanitary apparatus.

Chapter III explains **Advanced and Simplified Plumbing Methods,** and in connection therewith gives suggestions for vital improvements tending to modify and simplify the present methods, which are not, in the author's judgment, altogether satisfactory. For many years he has striven, in his practice, to secure the abandonment of costly and complicated plumbing systems in favor of those that are both simplified and safer, and he is gratified to note that a tendency towards this direction has recently set in.

Chapter IV deals with **Plumbing in its Relation to Preventable Disease** and with the Municipal Control of Plumbing.

Chapters V and VI deal with the problem of the **Supply of Water to Buildings.** While Chapter V refers to **Residences,** Chapter VI is devoted to the very important subject of the water supply of large structures and of the **Modern High Buildings.** Features which apply solely to the water supply of country houses are excluded from consideration, because they form one of the subjects of another book of the author.*

Chapter VII deals with the **Maintenance of Pipe Systems for Water, Sewage and Gas,** and is prepared chiefly for the use of managers of institutions, superintendents of buildings, householders and real-estate men.

Chapter VIII contains a complete set of **Rules** representing the best modern practice **regarding Plumbing, Water Supply and Sewerage,** chiefly with reference to hospitals and large public institutions, though the substance of the rules is also applicable to other classes of buildings.

The numerous Photographic Views and Text **Illustrations,** and the **Tables** and **Diagrams,** relating to water mains, service pipes, house sewers and kindred subjects, will, it is hoped, add much to the usefulness of the book. For some of these illustrations the author is under obligations to manufacturers of plumbing apparatus, and in the List of Illustrations the source is named from which each is taken. A number of the photographic views are from work installed under the author's direction.

Appendix A gives a **Definition of Terms** relating to sanitary engineering, water supply, sewerage and plumbing.

The **Development of the Drainage and Plumbing Methods** for Habitations from crude and imperfect beginnings to the present-day practice, is briefly reviewed in Appendix B.

Architects, building superintendents and sanitary engineers will find in the **Plumbing Specification Reminder,** Appendix C, under fifteen main headings or divisions, several hundred reminders regarding the materials, fixtures, workmanship and general contract conditions, which will be found useful in the preparation of plumb-

* See "The Sanitation, Water Supply and Sewage Disposal of Country Houses," published by D. Van Nostrand Co., 1909.

ing specifications. This reminder is the outcome of nearly thirty years' practical experience of the author in the preparation of specifications and in the superintendence of such work in buildings.

Several useful **Conversion Diagrams,** prepared by the author, are given at the end of the volume.

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Wm Paul Gerhard

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THE WATER SUPPLY, SEWERAGE AND PLUMBING OF MODERN CITY BUILDINGS.

CHAPTER I.

THE ESSENTIAL FEATURES OF THE HYDRAULIC AND SANITARY ENGINEERING OF BUILDINGS.

THE **Sanitary and Hydraulic Engineering of Buildings** comprises the sewerage, the removal and disposal of waste matters, the water supply, the lighting and ventilation, the plumbing work, the subsoil drainage, the dryness of foundation walls and of cellars, and in the case of rural houses the sewage disposal.

In its application to special buildings it embraces the sanitation of schools, hospitals, prisons and military barracks, and of abattoirs and market houses; the equipment of public baths; the fire protection of institutions; the safety measures for theater audiences; the sanitation of factories, workshops, summer hotels and resorts; and also railway and ship hygiene.

Architects are now recognizing the value of the services rendered by **engineering specialists,** and consider their work allied with their own profession. It is obvious that the plans and specifications prepared by a sanitary engineer must necessarily be more complete and exact than those of architects, who are expected to write the specifications for the work of a great many different trades, and who, in the nature of things, cannot be equally proficient in all of them.

But of even more importance and advantage than correct plans and specifications is the expert's personal superintendence of the work. Inasmuch as he looks after only one or a few special branches of building construction, he is much better able to give undivided attention to their numerous details, and to the thorough testing of the work during construction and after completion.

The **planning and installation of a water service, sewer system and of sanitary plumbing in large buildings** require a good deal of practical experience and an intimate knowledge of the subject and of the city ordinances, laws, rules and regulations pertaining to it. The sanitary expert must not only be familiar with hydraulic and sanitary engineering, but he should know something of structural engineering and of the properties of materials to be used in the work, and also be conversant with the preparation of plans and specifications, and with the laws bearing on contracts.

His services with the architect should begin when the structure is about to be planned and designed. If the structure is a large public building, the sanitary expert should start with a consideration of the functions of the building, the uses for which it is intended, the estimated number of permanent tenants as well as the probable number of transients which use such building, and which in some cases is very large. A thorough preliminary study of these features will enable him to decide upon the number of plumbing appliances required and upon the types which are the best to use in each individual case.

The number and location of plumbing fixtures being determined, the next step is to consider the minimum space required for them, and to lay out the fixtures on the plans in consultation with the architect so that they may be arranged to the best advantage.

For each type and kind of fixture the roughing measurements should be obtained and the fixtures as well as all pipe lines plotted on the plans in accordance therewith. Proceeding in this way, many serious errors, due to the unfamiliarity of architectural draughtsmen with such work, can be avoided.

When actual construction has begun, the expert assists the architect in the inspection of the materials, supervises all required tests, looks to careful workmanship (alignment, jointing, supporting, trapping, venting), sees to it that the work conforms to the plans and specification, makes sure that work is exposed where so wanted and that where intended to be concealed it conforms to the requirements before it is covered up, looks after the necessary protection of finished work, and at completion tests the working of all appliances and the efficiency of the water and sewer systems.

In this way the expert's services become invaluable to the architect and to his client.

An important branch of the work of the sanitary engineer relates to the **sanitary inspection of old and of new buildings** and of proposed building sites.

In a paper on "Sanitary Houses and How to Select One," written by an architect and quoted in Hasluck's book, "Sanitary Construc-

tion in Buildings," the importance of the subject is pointed out as follows:

> "In the olden days a habitation was merely a place to dwell in. In primeval times it might be a cave, with a few rough portions of rock placed before the entrance to act as a door; or it might have been a hole in the ground, with simply a few branches of trees covered over it to act as a roof; or it might have been an abode built in a tree, composed of nothing but branches twisted together, after the manner of a bird's nest, and probably suggested by it. All these, in the different climes, have been used as the home of man.
>
> "But necessity and the progress of civilization demanded a means of shelter more adaptable to varying circumstances, and the one-roomed hovel was built of rough stones, piled one on the other in rude unshapely masses, the crevices being filled with mud to keep out the wind and rain. Advancing further, the single room was made into two, then one was built above the other, mud was replaced by mortar, and bricks took the place of stones. One change brought another, and the house grew and increased step by step and stage by stage.
>
> "But, while civilization increased, and in nearly every science rapid advances were made, the science of sanitary building construction lagged woefully behind. Houses were built without reference to their surroundings, and regardless of proper means of drainage; no attention was paid to the circulation of air, nor to the nature of the subsoil; and as dwellings became more crowded in the vicinity of towns, unsanitary conditions increased both in number and in intensity."

Drainage of Town Houses. — In town houses, the requirement of thorough sanitation has come to be regarded as of so much importance that the installation of plumbing and drainage appliances, the connection with the street sewer, the provision for ample ventilation, etc., are made subject to municipal rules and regulations and to official inspection and supervision. The practice is, therefore, quite different from that of country-house work.

Owners of country houses are left to decide upon sanitary matters themselves, unless they choose the wiser course of seeking the advice of professional men, experts in their various branches. The health-favoring natural conditions of country life can be enjoyed in a perfect manner only where country houses, their surroundings, their water supply and sewerage are thoroughly *sanitary*.

The sanitation of the house is a most vital problem, equally essential and important in the case of city and of country buildings.

ESSENTIAL REQUIREMENTS OF SANITATION IN DWELLINGS.

The **sanitation of modern city buildings** comprises a great many requirements, each of which has a peculiar importance of its own. Some of these are briefly mentioned, although they do not belong to the scope of this book. All requirements, however, must be suitably observed or fulfilled.

The **essential conditions of healthfulness** are the following:

1. The building must be located on a proper site. This should be either naturally dry or rendered so artificially by adequate under-drainage.

2. The house should have a dry, light and well ventilated cellar. This serves several useful purposes, viz.:

(*a*) It contains the heating apparatus and the heating pipes;
(*b*) It contains the main drainage system for the plumbing of the house;
(*c*) A part of the cellar is subdivided into bins of suitable size to hold the fuel for the kitchen range, the fireplaces and the heating apparatus;
(*d*) It has separate well-arranged compartments for the storage of provisions, and
(*e*) A separate wine cellar.

3. The superstructure of the house must be dry. Dampness of walls, which is so prevalent in many houses, is a well known cause of ill-health. Damp basements, in particular, are an abomination not to be tolerated for an instant.

4. The building should have a sanitary system of house drainage and plumbing. This does not comprise merely, as laymen are prone to think, the plumbing appliances, in the selection of which there is nowadays less trouble than in former times, owing to the excellent character of the many types of sanitary fixtures manufactured in this country, but it includes what is really vastly more essential, namely, the safe trapping of all fixtures and the correct arrangement of all drain, soil, waste and vent pipes.

5. Houses should be provided with an abundant supply of pure and wholesome water flowing everywhere under a good pressure. For laundry, bathing and general ablution purposes provision must be made not only for cold but also for hot water. A plentiful

water service, available under high pressure, furnishes a splendid and much-needed fire protection, which is required for city buildings not less than for the country mansions located miles away from the nearest village fire department.

6. All habitable rooms of the house, and in particular the sleeping-rooms, should be efficiently ventilated. For winter occupancy the building should be well heated, and living-rooms and halls should be kept at a uniform temperature. All rooms should be well-lighted in day time, and the artificial lighting system provided for the evening hours should be safe and free from any sanitary objection.

7. The storm water from roofs, areas, courts and yards should be efficiently removed, and drippings from roofs, balconies or from porches, tending to keep the foundation walls damp, should not be tolerated. If there is a tendency of water accumulating in the cellar, this should have proper drainage. The cellar drain should not be directly connected with the sewerage system of the house.

8. The house should have a perfect sewerage system, by means of which all liquid household wastes are instantly removed from the building.

9. All garbage, kitchen offal or other solid waste matter and refuse, not intended to be, or not capable of being, removed by the house sewer should be promptly and regularly removed and disposed of in a safe and sanitary manner.

10. The sewage from the house should be run to the street sewer; in outlying unsewered city districts a proper sewage-disposal system, rendering the sewage innocuous, should be planned and carried out. Leaching cesspools and privy vaults should not be tolerated on city premises under any circumstances.

11. If there are any minor buildings, such as a stable or, in the case of suburban houses, cow barns or other buildings where domestic animals are kept, these should have simple sanitary arrangements.

It is a mistake frequently committed by owners to economize in the matters of water supply, house drainage and sewage disposal. Purely ornamental features of the residence may be omitted until a more opportune time, where economy must be practiced; but under all circumstances one should feel sure that the water supply is un-

contaminated, that it is preserved and maintained in a pure condition, and that the sewage from the house is disposed of in a proper manner, and in such a way as not to give, in the course of time, offense to sight or smell, or to cause preventable illness.

Drainage of Building Sites. — In all those instances where the soil holds an excess of moisture, or where there are springs within or near the foundations, the building site must be underdrained. This is an important requirement for the salubrity of habitations. The drainage of sites is accomplished by the use of porous or unglazed round drain tiles, which are made in sizes from 1½ to 6 inches, and in one- and two-foot lengths. These drain tiles are laid with open joints in order to gather the water, the joints being protected against obstructions by pipe collars, or else by plain muslin wrapped around the joints. Formerly stone drains were used for this purpose, but it was found that they stopped up and were not self-cleansing. Drains are laid in generally parallel lines, at distances varying from 20 to 50 feet. Lateral drains, from 2 to 4 inches in diameter, are connected with the larger main drains, which should not connect with foul-water sewers.

In the case of detached houses, in the suburbs or the country, the drain outfall may go to an open road ditch or to a water course. In city houses, however, usually no outlet for the subsoil water other than the house sewer is available. The subsoil drain must therefore be properly trapped to prevent gases from the soil pipes or the sewer from gaining access to the drains; the water seal of the trap should be permanently maintained by introducing a roof-water pipe, or by other special devices.

Foundation Drains. — To secure **dry foundation walls,** tile drains are laid along the footing courses and the drain trench is filled with broken stones and gravel. For houses on a hillside, a good plan to secure dry walls and dry cellars consists in building a drain above the upper side of the house, which intercepts subsoil and surface water, and which conveys it around the building toward an outlet below the house.

Excessive moisture in the soil under habitations, damp foundation walls and wet cellars are the causes of pulmonary diseases, consumption, diphtheria, malarial fever, etc. The **drainage of a** house is therefore just as important as its **sewerage.**

Removal of Storm Water. — In a wider sense, the term "drainage" includes the removal of storm water from roofs, areas, courts, yards and balconies of buildings. The roofs of habitations are drained by means of the gutters, the conductor heads and the leader or conductor pipes. These pipes are placed either on the outside or on the inside of houses.

In cities which have introduced the "separate system of sewerage," the rainfall is excluded, partly or wholly, from the sewers. A special pipe system for leader and yard drainage is, therefore, required, and the roof water may be conducted into storage tanks or cisterns. In other cases the rain water is carried away by special rain-water channels. In those cities which are sewered on the "combined system" the rain water is carried off by the same conduits which receive the house sewage, and in all such cases the leader, yard and area drains should be efficiently trapped.

Road and Street Drainage. — A system of road or street drainage accomplishes the removal of the water falling upon the roads and the streets by means of paved and graded gutters, by road boxes, street catch-basins and underground conduits.

Country-House Drainage. — The term "country-house drainage" is often improperly used to designate the method adopted for the removal and disposal of the sewage from country houses. Thus the sentence "a house drains into a cesspool" is intended to mean that the sewage is delivered into an underground hole or sunk pit, generally bricked or stoned at the sides and covered at the top, in which the solid or liquid waste matters from habitations are temporarily stored.

Cesspools. — Open or leaching cesspools pollute the water of springs, of wells and of cisterns, and frequently become the cause of typhoid fever. Water-tight cesspools, if not located too near to a dwelling, are sometimes unobjectionable, but the frequent pumping out which they require is troublesome, annoying and expensive. In the denser parts of cities, cesspools should be absolutely prohibited by Board of Health rules; for outlying districts of cities which are not included in the general sewerage system, cesspools may be tolerated as a temporary measure, but they should be constructed water-tight, and emptied at frequent intervals, and this should be done under special Board of Health regulations.

Sewage Disposal. — A better system of disposal for the liquid sewage from isolated houses in outlying districts of towns, where houses are not located close together, and for institutions within the city limits, but not in reach of sewers, is by means of either the surface or the subsurface irrigation systems. The sewage is collected in a small tight flush tank and is discharged, by means of an automatic siphon device, into a drain or conduit which leads to a sewage-disposal field. Here the sewage is distributed over the land, on the surface, in open ditches or channels, or else it is discharged into porous absorption tiles, laid in more or less regular lines, with a slight fall, and at a depth of from 12 to 16 inches below the surface.

Where land for sewage disposal is not available, a good purification may be effected by some of the modern biological systems, involving the use of septic tanks for a preliminary purification, and of contact filter beds and of percolating or trickling filters for a more thorough treatment of the sewage. This subject is treated more fully in other works of the author. (See list at end of book.)

Agricultural Drainage. — The art of carrying off surplus water from swampy districts, from hard clay soils, or from land subject to excessive flooding during rainy weather, is usually known as "agricultural drainage"; it is of much benefit to vegetation and to crops.

House Drainage. — Included in the term "house drainage" are all the arrangements required in habitations for the removal of the sewage and the befouled water supply. A speedy removal of foul wastes is desirable, and to accomplish it systems of drain, soil, waste and vent pipes and of plumbing fixtures, with traps and other appurtenances, are required. In many cases the pipes for the removal of storm water from roofs, yards, courts and areas are included in the system.

Of late years, house drainage has become such an important factor in the interior equipment of buildings as to render it desirable or preferable to leave the subject to be dealt with by educated and skilled civil engineers who make a specialty of sanitary work.

Objects and Essentials of a House-Drainage System. — The chief objects of a sanitary house-drainage system are the following:

(*a*) To remove from a building as rapidly and completely as possible and as soon as produced all liquid wastes and waste matter capable of being transported by water, including fæcal matter, without any pollution of the soil or of the water supply.

(*b*) To effect this removal in such a way that no sewer air, whether from the street sewer or the house pipes, can gain entrance to the interior of a house through the outlets of fixtures or at any other point or place, and that the air around the house may not be contaminated with noxious gases of putrefaction.

To accomplish the objects stated, it is necessary to provide and install sanitary plumbing appliances, connected with a well-arranged and perfectly ventilated soil-pipe system; the fixtures and waste pipes should be safely trapped; the drain-pipe system should be both air and water tight; the traps and pipes used should be of proper material, sizes and thicknesses; the drains should be laid with a proper fall to render them self-cleansing, and should have branches and junctions properly made to prevent stoppages. The perfect accessibility of all parts of the system for the periodical inspection, cleaning and testing operations is an essential requirement.

General Arrangement of the System of House Drainage.

The illustration, Fig. 1, shows in general outlines the manner in which the drainage of a house should be arranged in accordance with modern principles of sanitation.

Sewer Connection. — Every building should have a separate and independent connection with the sewer in the street.

House Sewer. — Where a proper foundation of either earth or rock can be obtained, the **house sewer,** connecting with the sewer in the street, may consist outside of the building of glazed vitrified or stoneware pipe. But in made ground or where there is danger of settlement of the pipes, the house sewer from the building line to the connection with the street sewer should be of heavy cast-iron pipe with lead-calked joints. In all cases the vitrified pipe should terminate about five feet outside of the walls.

House Drain. — Inside of the building the **house drain** should be carried, wherever possible, above the cellar floor, and be supported at intervals of about ten feet by brick piers; in some cases it is suspended from the ceiling by means of heavy iron pipe hangers. When laid underground, the house drain should consist of heavy cast-iron pipe; but where run above ground, it is sometimes made

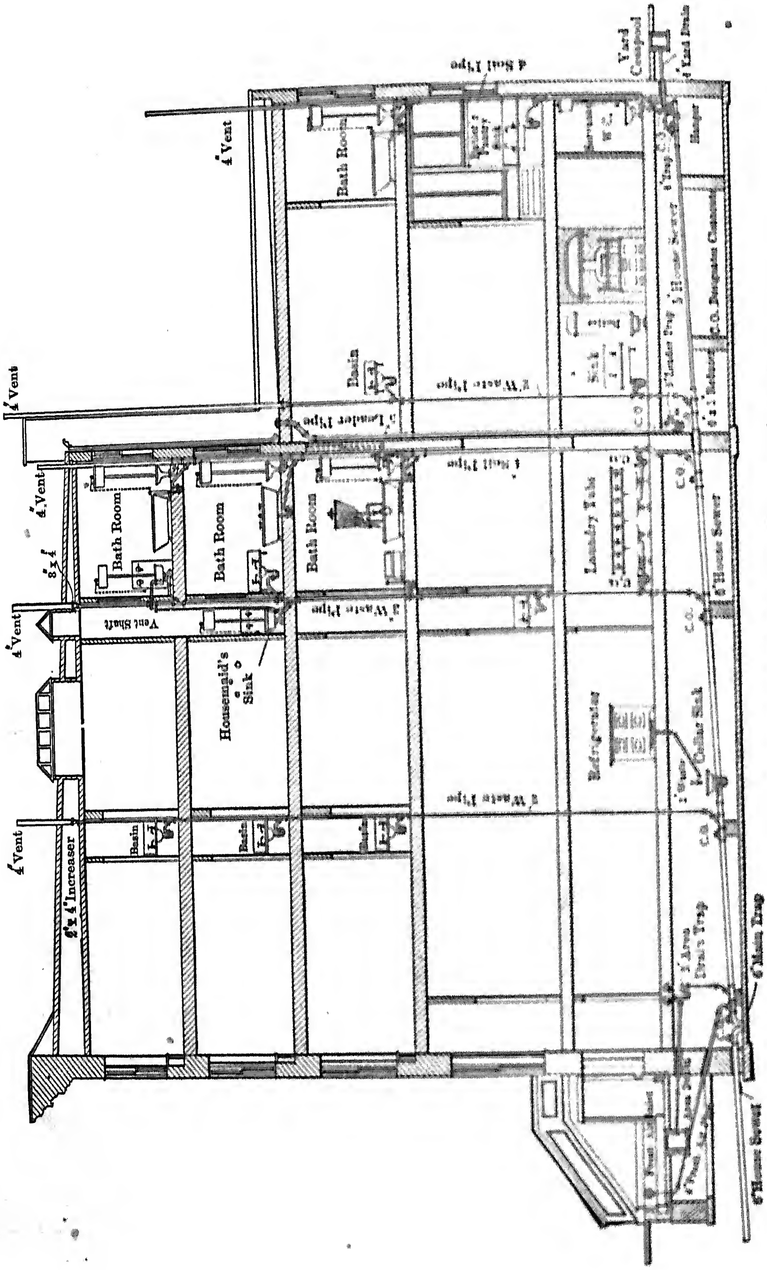


FIG. 1. Arrangement of a House Drainage System.

of tarred, galvanized or asphalted wrought iron, with screw joints and recessed drainage fittings.

The house drain should be run as direct as possible, and with a minimum fall of one-quarter inch per foot. Proper fittings should be used for changes in direction, and connections with vertical soil and waste lines and with leaders should be made with Y branches and one-eighth or one-sixteenth bends. Full-size Y and Tee-branches with openings closed with brass screw caps should be provided as clean-outs.

Sizes of House Sewers. — The diameter of the house sewer depends chiefly upon the grade or inclination given to it and upon the number of plumbing fixtures in the building. But where it also receives the rain water, the size of the lot to be drained and the amount or rate of rainfall govern the size.

In Greater New York, for instance, the sizes of house sewers are determined upon the basis of a rainfall at the rate of 6 inches per hour, and it is assumed that the house sewer runs nearly full, with a velocity of at least 4 feet per second.

Table I gives the area of lots drained by different sizes of pipe according to the above data.

TABLE I.

Diameter of Pipe in Inches.	Grade of Sewer ¼″ per foot.	Grade of Sewer ½″ per foot.
4″	2000 sq. ft.	2500 sq. ft.
5″	3000 "	4500 "
6″	5000 "	7500 "
7″	6900 "	10300 "
8″	9100 "	13600 "
9″	11600 "	17400 "

It is not, however, always necessary to provide for such extreme amounts of rainfall. Generally, small houses are satisfactorily drained by 4-inch sewers; a 5-inch sewer answers for a large city house, and 6-inch sewers are required only for very large buildings. An empirical rule requires 1 square inch sectional area of house drain for each 15 gallons of sewage or roof water per minute.

Regarding the maximum volume of sewage which may be discharged through a house sewer of a large building provided with a large number of fixtures, only approximate estimates can be made. To arrive at a fair figure one should consider the total number of fixtures, assume a certain number of gallons for the discharge of each, and further assume that not more than one-half (or one-fourth or one-fifth as the case may be) of the total number would be likely to be emptied simultaneously. By allowing for each water-closet discharge 6 gallons, for each urinal 3, for each lavatory 2, for each sink 4, and for each bath tub 40 gallons, the volume of sewage may be calculated, provided one also takes note in the calculation of the time required for the emptying of these fixtures. The water-closet will discharge the quickest, next the urinals, basins and sinks, while the bath tubs will require more time in emptying.

For buildings covering a wide area it is better to provide two or more 6-inch sewers rather than have one 8 or 10 inch connection. The smaller the pipe, the larger must be the inclination given to secure a velocity of flow sufficient to prevent deposits.

TABLE II.

Table Giving the Discharge of Vitrified and Iron House Drains, of Different Diameters, and Laid at Various Grades, in U. S. Gallons per Minute, Pipes Running Full.

VITRIFIED PIPES.					IRON PIPES.				
Rate of Inclination.	Diameter in Inches.				Rate of Inclination.	Diameter in Inches.			
	4	5	6	8		4	5	6	8
1:10 or 6/5" per ft.	271	505	840	2138	1 : 10 or 6/5" per ft.	253	472	787	2012
1 : 20 or 3/5" per ft.	192	358	596	1521	1 : 20 or 3/5" per ft.	179	334	558	1426
1 : 30 or 2/5" per ft.	157	293	486	1236	1 : 30 or 2/5" per ft.	146	274	456	1156
1 : 40 or 3/10" per ft.	135	252	420	1061	1 : 40 or 3/10" per ft.	127	236	394	998
1 : 50 or 1/4" per ft.	122	227	377	966	1 : 50 or 1/4" per ft.	114	212	353	903
1 : 60 or 1/5" per ft.	111	206	344	887	1 : 60 or 1/5" per ft.	103	193	322	824
1 : 70 or 1/6" per ft.	103	192	318	808	1 : 70 or 1/6" per ft.	97	179	299	760
1 : 80 or 1/7" per ft.	95	179	298	760	1 : 80 or 1/7" per ft.	90	168	279	713
1 : 100 or 1/8" per ft.	86	160	266	681	1 : 100 or 1/8" per ft.	79	149	249	634
1 : 200 or 1/16" per ft.	60	112	189	475	1 : 200 or 1/16" per ft.	57	106	176	444

Discharge of House Drains. — The comparative smoothness of the inside of house drains has an influence upon their discharging capacity. Smooth vitrified pipes deliver more water than rough cast-iron pipes. Table II gives the discharge in U. S. gallons per minute of smooth vitrified and of rough cast-iron pipes of different diameters, laid at various grades, and running full.

Where sufficient fall cannot be obtained, flushing arrangements should be provided. House sewers should have tight joints to prevent leakage and contamination of the soil under and around habitations, or the pollution of the drinking-water in wells in the country.

Main Running Trap and Fresh-air Inlet. — A **running or house trap** should be placed on the house drain near the front wall and be kept accessible by means of a manhole with iron cover. This trap should have two clean-outs with brass screw caps, one on each side of the water seal.

A **fresh-air inlet pipe** should connect with the house drain on the house side of the trap and be extended to a point outdoors at least fifteen feet away from a window or from a cold-air box or conduit for the heating apparatus. Where practicable, the fresh-air inlet should terminate one foot or more above grade level, and be fitted with a quarter bend with brass strainer (such as Desper's fresh-air inlet strainer). In many cases this desirable arrangement is not feasible, and the fresh-air inlet is made to open into a brick or iron

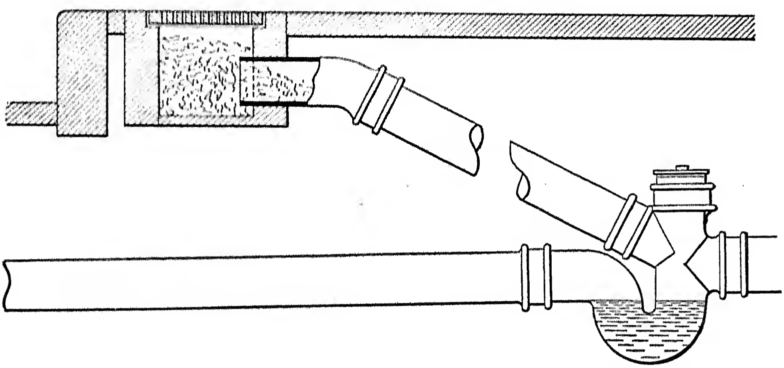


FIG. 2. Objectionable Arrangement of Fresh-air Inlet.

box in the sidewalk flagstones, and is fitted with removable metal grating, leaded into the stone, with openings equal in area to that

of the fresh-air pipe, and not less than ½ inch in their least dimension (Fig. 2).

It has been found a difficult matter to prevent the stopping up of these fresh-air inlet gratings. In Figs. 3, 4 and 5 are illustrated

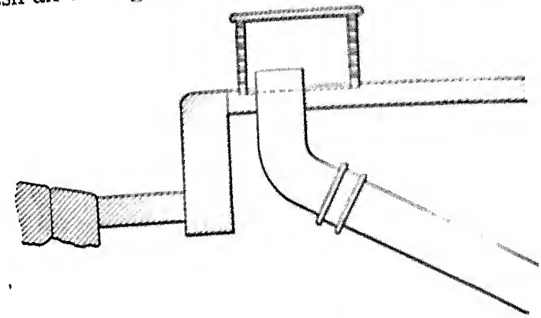


FIG. 3. Arrangement of Fresh air Inlet.

some suggestions for the arrangement of fresh air inlets, which show methods by which obstructions and stoppages may be prevented. Fig. 6 shows a fresh-air inlet located near an iron fence and hidden from sight by shrubbery. It is provided with a new style of fitting, shown on a larger scale in Fig. 7, which is manufactured by the Hydraulic Specialty Company of Philadelphia. It provides a flushing rim inside of the air inlet, and by running a supply pipe to it, controlled inside of the house by a stopcock, the flushing of the fitting and of the inclined portion of the air inlet pipe may be effected.

A similar device in use by the plumbing department of the New York Board of Education consists of an iron box set in the sidewalk with flushing connection. Another method is shown in Fig. 8, and consists of an automatic tank set in the cellar, which controls the supply to the fresh-air inlet pipe, and which can be set to flush at regular intervals as desired. This latter method has been suggested by the J. L. Mott Iron Works.

The fresh-air inlet constitutes a foot ventilation for the soil-pipe system at its lowest point, and serves to induce a circulation of air through the house pipes. The mouth of the fresh-air inlet pipe should always be placed at some distance from the building.

Where street sewers are constructed in accordance with a well-conceived plan, and where they are well flushed and ventilated,

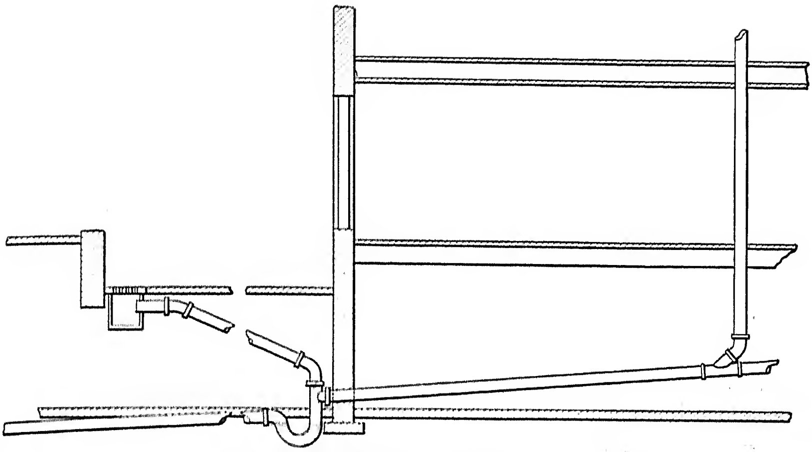


Fig. 4. Arrangement of Fresh-air Inlet.

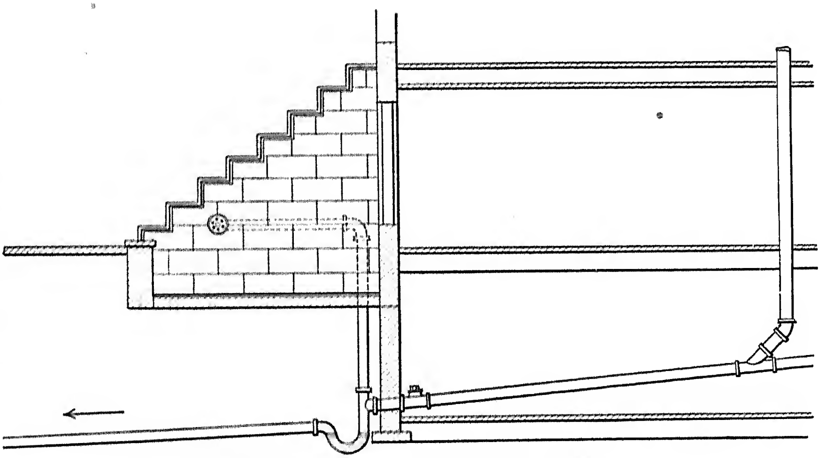


Fig. 5. Arrangement of Fresh-air Inlet.

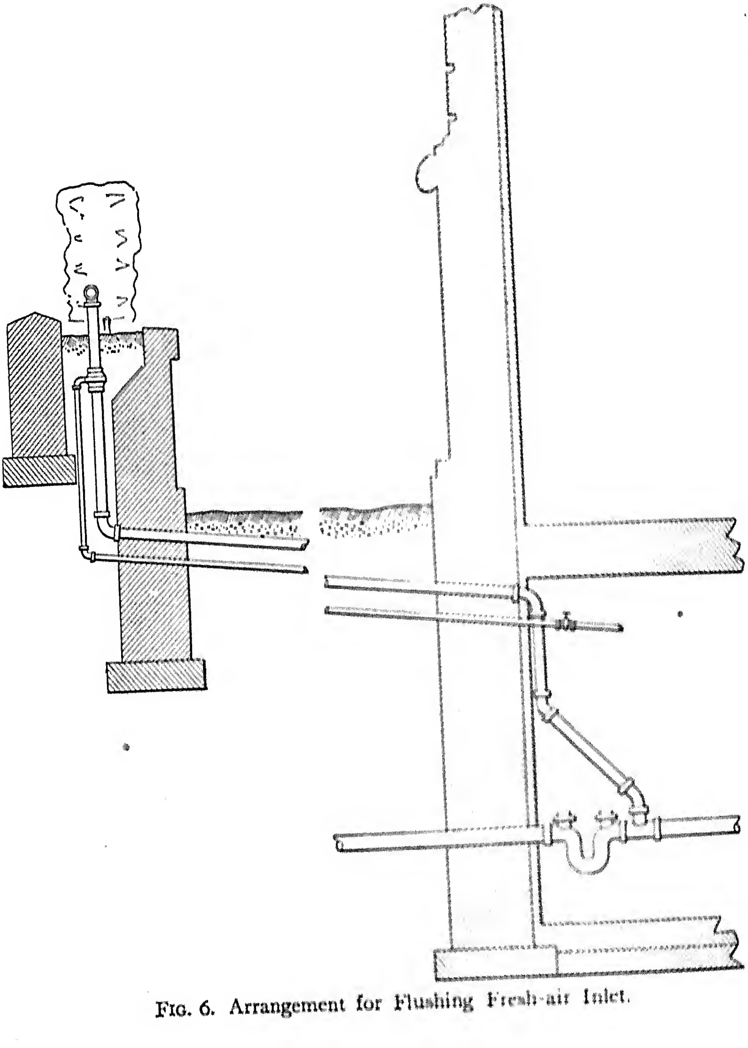


FIG. 6. Arrangement for Flushing Fresh-air Inlet.

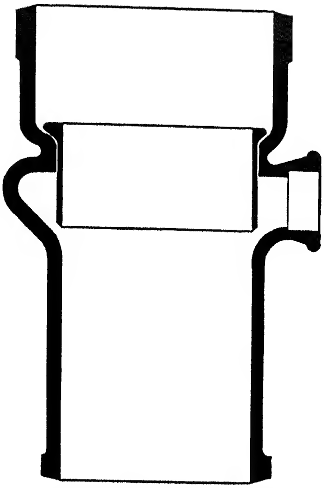


FIG. 7. Fitting Used for Flushing Fresh-air Inlet.

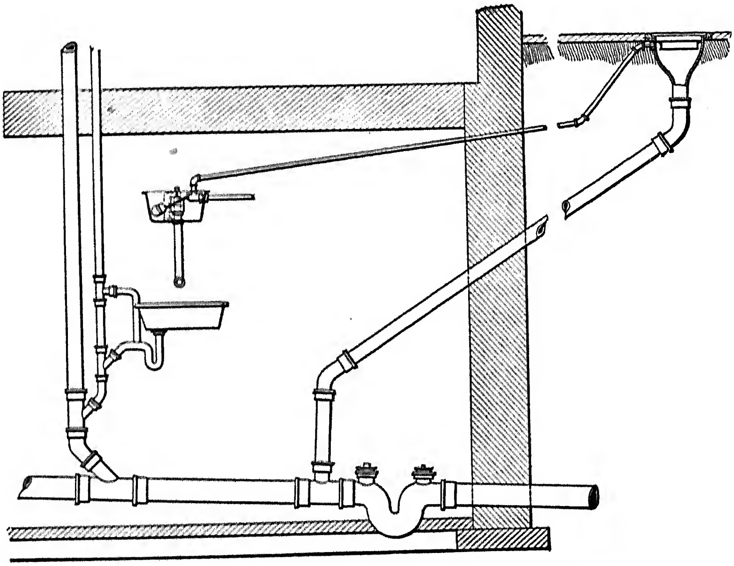


FIG. 8. Arrangement for Flushing the Fresh-air Inlet.

and the house piping tested to secure absolute tightness, it is better to omit the main house trap and the fresh-air inlet. In such case the soil-pipe system receives air from the ventilating manholes on the line of the street sewer.

Drainage of Yards, Areas and Courts. All yards, areas and courts should be paved and drained by pipes not less than three inches in diameter, and these pipes should be trapped and the traps set in the cellar.

Cellar Drains. — Cellar drains should be permitted only where they can be connected with a trap having a permanent water seal.

Leader or Rain-water Conductor Pipes. All city buildings should be provided with metal leaders of proper size for conducting the roof water into the sewer, thereby protecting the walls and foundations from injury. The water from leaders should not be permitted to flow over the sidewalk. When leaders are placed inside of houses, they should be made of cast iron, wrought-iron or steel pipe, and their connections with the roof should be made air and water tight by means of heavy lead or copper tubing, soldered to a brass ferrule or nipple, which in turn is calked or screwed into the iron pipe.

Outside leaders usually consist of sheet metal, either copper or galvanized iron, except that their connection with the house drain is made by means of cast or wrought iron pipe run to a height of at least five feet above grade level. All leaders should be trapped with running traps so placed that they cannot freeze. Rain-water leaders should never be used as soil, waste or vent pipes, and none of these pipes should ever be used as leaders.

Sizes of Leaders. — The usual sizes of leader pipes are 3, 4, 5 and 6 inches; larger sizes are rarely used. The diameter and the number of vertical leaders for a given roof area cannot be calculated by hydraulic formulæ.

An empirical rule, which I have used with success, is to allow 1 square inch sectional area of leader pipe to from 70 to 150 square feet of roof surface, this depending upon the amount of rainfall and the slope of the roof.

Others allow 1 square inch sectional area of leader to 250 square feet of projected roof surface.

Thus a roof 75 feet by 50, or 3750 square feet area, would require in the one case $\frac{3750}{150} = 25$ square inches, and in the other $\frac{3750}{250} =$ 15 square inches leader area, or in one case a 6-inch, in the other a $4\frac{1}{2}$-inch pipe.

Location of Main House Sewer. — It is the better practice to carry house drains exposed above the level of the cellar floor; hence plumbing fixtures located in the cellar should be avoided. The drain pipes should consist of heavy iron pipe, either cast-iron plumbers' soil pipe or heavy screw-jointed wrought-iron pipe. Cast-iron pipes above the cellar floor should be left unpainted and untarred, for the paint and the tar cover up sand holes and other defects. The wrought-iron pipes are protected against rust by asphalting or galvanizing.

Junctions and connections should be made with Y branches, for right-angled or Tee connections impede the flow and tend to create stoppages. Changes in direction should be made under an angle of 45 degrees. No short quarter bends should be used. Cleaning hand-holes should be provided at traps, bends, junctions, and at the upper ends of the lines.

Soil and Waste Pipes. — The soil and waste pipe system of buildings consists of extra heavy cast-iron pipes, or of steel or wrought-iron pipes, or finally, though only in rare cases, of brass. The wrought-iron and steel pipes are galvanized, and special heavy cast or malleable iron recessed drainage fittings with a smooth interior waterway are used with them. The joints of cast-iron pipe are calked gas-tight with molten lead and picked oakum; the joints of wrought-iron, steel and brass pipes are screw joints.

The advantages of a screw-jointed soil and waste pipe system are rigidity, permanent tightness of the joints, and fewer joints, as the pipes can be used in long lengths. In large and in high buildings the screw-jointed system is now generally preferred, but it is also used in many of the best modern city residences.

Sizes of Soil and Waste Pipes. — Table III gives the usual sizes of soil and waste pipes and of the lateral branches for the fixtures.

TABLE III.

Main Soil Pipes in Dwelling-Houses.	4 inches.
" " in large Buildings of more than 4 stories, and in Tenements, Factories, Schools, Hospitals for Insane, etc.	5 "
Waste Pipes in Dwellings.	2 "
" " in Buildings of more than 4 stories.	3 "
Branches for Water-closets	4 "
" " Slop Sinks.	3 "
" " Kitchen Sinks.	2 "
" " Pantry Sinks.	1½ 2 "
" " Bath Tubs.	2 "
" " Spray, Douche or Needle Baths	3 "
" " Foot Tubs, Sitz Tubs, Bidets	1½ "
" " Single Wash Basins.	1½ "
" " Row of Wash Basins.	2 "
" " Set of Laundry Tubs	2 "
" " Each Washtub.	1½ "
" " One Urinal.	1½ "
" " Row of Urinals.	2 "
" " Stall Urinals in niche form, and Trough Urinals.	3 "

Roof Extensions. — To prevent any pressure of air in the pipes, and to ventilate the system, all soil and waste pipes are extended in full size up to and at least two feet above the roof. *Vent extensions* at the roof should always be carried either in a vertical line or by 45-degree offsets, as shown in Fig. 9. The mouths of the pipes on the roof should not be capped with cowls, return bends or with vent caps (Fig. 10) all of which impede free ventilation. It is best to leave the pipe mouths wide open and unobstructed. The pipes should be kept away from light shafts, from windows, chimney flues or ventilating openings. The stacks should be carried as straight as possible through the building. On all floors the proper fittings should be provided for fixture connections. The necessary offsets in soil pipes above the highest

fixtures, and all offsets in vent pipes, should be made at an angle of not less than 45 degrees to the horizontal, to prevent the lodgment of rust in the pipe.

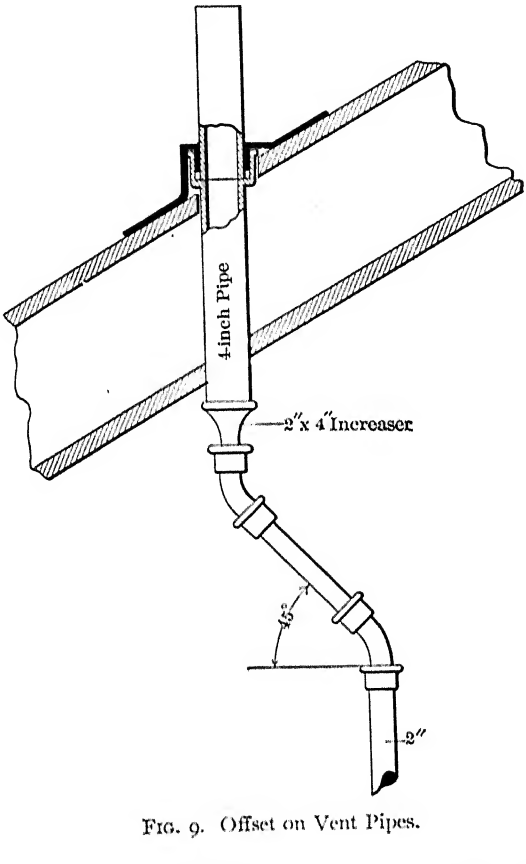


FIG. 9. Offset on Vent Pipes.

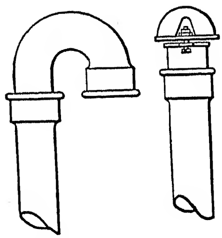


FIG. 10. Objectionable Forms of Vent Terminals.

Branches for Fixtures. — Lead waste pipes of heavy weight are used only for the short branches connecting the fixtures with the soil and waste lines. Where practicable, the fixtures should have separate connections to the vertical stacks.

Plumbing Regulations. — In many cities, plumbing is now governed by regulations and watched over during construction by city inspectors. The enforcement of official *plumbing regulations* and the municipal inspection of plumbing are matters of much importance and will be dealt with in Chapter III.

Tests of Plumbing. — All work should be tested to guard against defects in material or workmanship. The soil, drain, waste and vent-pipe system, or the "rough work" in new buildings, is tested under hydrostatic pressure by closing all outlets before the fixtures are set and filling the pipe system with water. The complete work is again tested by an oil-of-peppermint test or by a smoke test. Such tests are also useful in the examination of the drainage arrangements of old dwellings.

Smoke Test. — There are several efficient **smoke testing machines** in the market and some of the best known are illustrated in my book "Sanitary Engineering of Buildings."

In Fig. 11 I illustrate the "Monitor" testing machine, which is one of the latest introduced, and which I have found free from

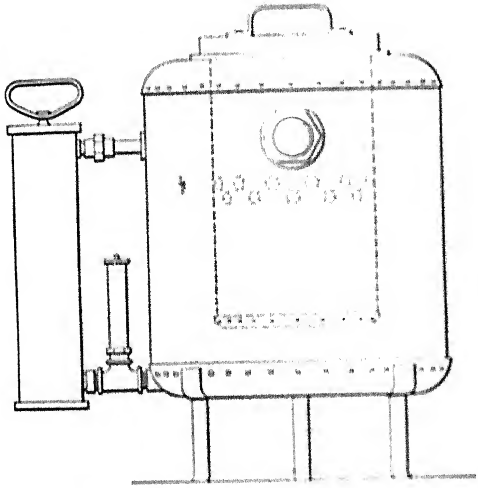


FIG. 11. Smoke Testing Machine.

complications, reliable in operation and simple in action. It is compact and durable in construction, the body being made entirely of copper with riveted head and bottom, and the inside chamber of heavy galvanized sheet steel. It is easily handled and can be readily carried through a house.

The smoke generated in this machine is forced into all parts of the soil, waste and vent pipes by a brass force pump which is easily operated, and which maintains any pressure desired in the pipes after they are filled with smoke.

The machine is made in several sizes, and the smallest is sufficient to fill the pipe system of a four-story dwelling-house in a few minutes. It is provided with a gauge to indicate when the pipes are filled and to prevent the blowing out of the traps. All parts

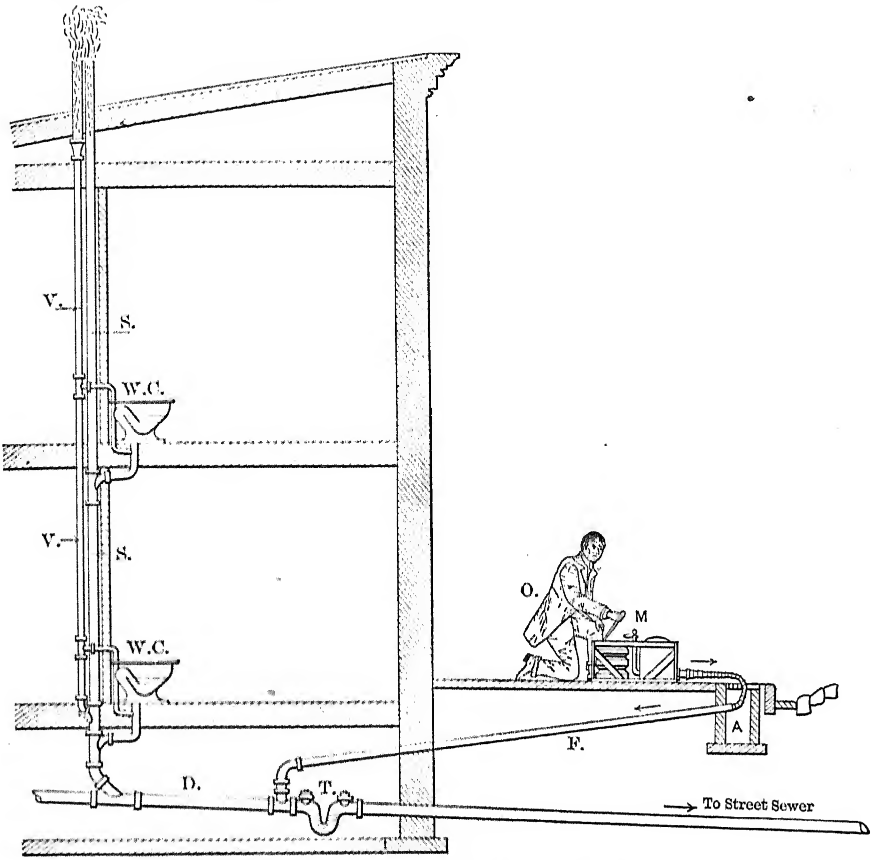


FIG. 12. Application of the Smoke Test.

of the machine are readily accessible for cleaning, and none of the working parts are liable to clog up.

The machine can also be used for disinfecting purposes by substituting for the chamber in which the smoke is generated from burning tar paper a separate chamber containing the required chemical disinfectants.

The practical application of the smoke test for testing the drainage of buildings is shown in Fig. 12.

Cellar Drainers. — When small quantities of clean *subsoil water* are to be removed by lifting them up to the higher sewer level, simple cellar drainers are used, which generally operate by water pressure, though sometimes high-pressure steam is used in connection with steam ejectors.

The Braender cellar drainer has the following capacities with a maximum lift of 12 feet:

No. 1. 375 gallons per hour.
No. 2. 600 gallons per hour.
No. 3. 1275 gallons per hour.

It requires for every foot of lift about 5 pounds pressure. The Kemp "Climax" cellar drainer operates with a water pressure of 15 pounds or more, and the sizes and capacities are given in the following Table No. IV.

TABLE IV.

Capacities of Cellar Drainers.

Sizes.	Capacity in Gallons per Hour.	Size of Supply in Inches.	Size of Discharge in Inches.
1	50 to 250	½	1
2	100 to 400	¾	1¼
3	150 to 600	1	1½
4	200 to 800	1¼	2
5	275 to 1000	1½	2½
6	350 to 1200	2	3

The water pressure required ranges from 15 to 80 pounds, and the lift from 6 to 12 feet.

Sewage Pumps and Automatic Sewage Lifts.

The foundations of many modern city buildings reach so deep below the street grade as to render it impossible to drain the lowest fixtures or the lowest floors by gravity flow to the street sewer. In such cases recourse must be had to the **pumping of the sewage,** and this can be accomplished in various ways.

Sewage Pumps. — The sewage may be lifted from the level of the basement or sub-basement, as the case may be, to the gravity sewer

on the higher level by pumps, which are generally made automatic, and which in cases where electric current is available are operated electrically. The choice of the style of pump depends upon the character of the waste water to be lifted. Where this is merely clean waste water, drips from machinery, etc., **piston pumps** may be used. Where sewage containing much coarse suspended matter, grease and excrements must be lifted, such pumps can be used only if the sewage is carefully screened, which, in city buildings, would lead to undesirable conditions. Where the waste matters contain chemicals in large quantities, particularly acids, piston pumps are not advisable. The majority of such plants make use of **centrifugal pumps** (Fig. 13), which are particularly adapted to low lifts but which in recent years have been so modified as to make them

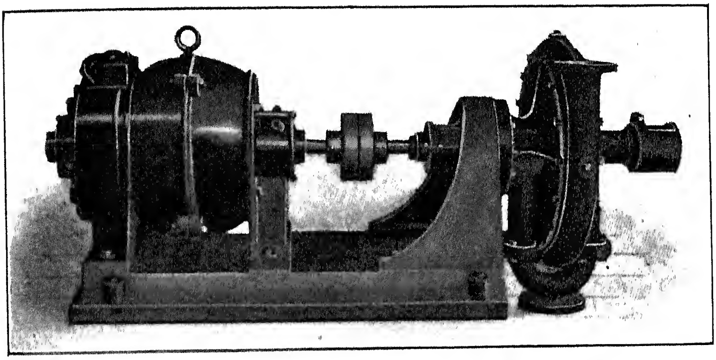


FIG. 13. View of Lawrence Centrifugal Sewage Pump.

also adapted to higher lifts. These pumps are made **automatic** by placing a float in the sewage receiving tank and connecting it by means of pulleys to an automatic starting device.

In all cases a receiving tank or reservoir for the waste water or sewage must be provided, and this should be made of generous size. It is set up either on the same floor level with the pump, or else it is located below the level of the lowest floor in cases when it is necessary to drain this floor. The former location is much to be preferred, particularly in the case of centrifugal pumps, because set up in this way the pump always remains primed, and requires no foot valve and no special devices to be operated by hand or automatically for the purpose of charging the pump and starting it.

Where **sump tanks** below the cellar floor must be used, it is now usual to install **submerged centrifugal pumps,** and in this way the difficulties mentioned above may be overcome. The motor driving these pumps is set up directly vertically over the pump, and the two are connected by a direct vertical shaft. A foot valve on the suction of the pump is not required for submerged pumps, and thus another troublesome feature of these systems is avoided. The drawback is that the pump cannot be reached for inspection and repairs without drawing it up.

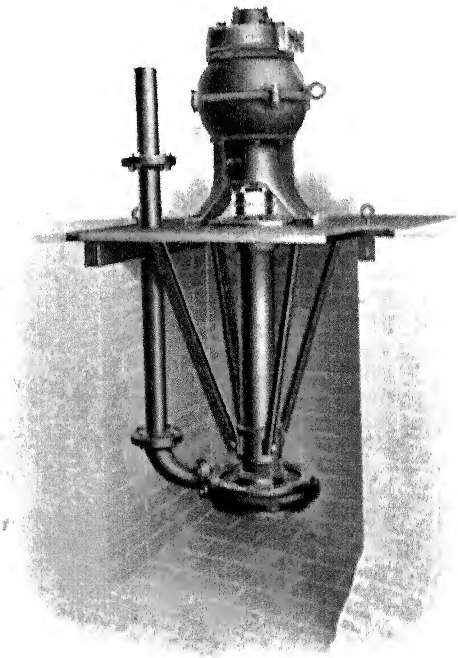


FIG. 14. View of Quimby Submerged Centrifugal Pump.

Among the many submerged centrifugal pumps used for the purpose of draining basement sump pits the Quimby sump pump is one of the latest and best. It is shown in Fig. 14, and is usually installed with float valve and automatically operating switch. This pump runs with very little attention, except occasional oiling, and it is constructed with a view of handling not only

water but also water containing more or less coarse solid matter and grit.

One of the advantages of submerging a centrifugal pump is, as stated above, that it does away with special priming arrangements and with foot valves. In this style of pump the bearing which carries the vertical shaft on which the impeller is fastened is located at the level of the sump pit cover and not at the pump, below the water line. It is ball-bearing and has a large oil receptacle for lubrication. Diagonal braces serve, as shown, to obtain rigidity of the vertical shaft.

The pump is attached rigidly to a plate forming a part of the cover of the sump pit. By lifting the iron plate cover the pump is simultaneously lifted out bodily, and in this way all its vital parts are easily accessible at all times. The pumps are made in sizes varying from 30 to 250 gallons' capacity per minute. In determining the size of pump and motor, one should know or calculate the amount of water to be lifted, the total vertical distance between bottom of sump pit and high-level sewer, also the length and size of the discharge pipe, and the number and kind of bends in the discharge line.

Sewage tanks should always be provided with a large-sized vent pipe to the roof, and likewise with a separate fresh-air inlet for ventilating purposes. It does not seem to be advisable to intersect the sump vent into any of the regular vent stacks for the plumbing of the upper floors.

The tanks are usually made of boiler iron, and may be either closed or open tanks. The closed tanks are somewhat preferable, chiefly where sewage enters the tank. For clean wastes the tank may have a removable cover.

Automatic Sewage Lifts. — Several styles of apparatus for lifting larger volumes of sewage automatically from a low to a higher level have come into use in recent years. The first one introduced into this country was the **Shone sewage lift or ejector,** an English invention of much merit. It consists essentially of a tight cast-iron receiver for the sewage, provided with inlet and discharge pipes, and with float, which operates automatically in opening and closing an air valve, by which compressed air from a storage tank is admitted to the ejector. The compressed air acts directly upon the accumu-

lated liquid and ejects it into the discharge main. There are no other mechanical parts to the system. The discharge is accomplished quickly and generally quite noiselessly. The ejectors are tightly closed receptacles, and hence there is no smell from the sewage. The entire operation is automatic, and there is very little to get out of order in such apparatus. To guard against any interruption of the flow, and to enable the making of repairs if such should become necessary, it is always advisable to install the ejectors for sewage in duplicate as for instance in Figs. 16 and 17.

The size of the receivers for sewage depends somewhat upon the quantity of sewage to be dealt with per minute. It is my experience that a small apparatus, or several of these, set up in battery form as shown in Figs. 20 and 21, accomplish the work much better, and possibly more economically, than very large ejectors. The emptying of the ejectors does not take very long, and they are at once ready to receive more sewage. Where the flow is intermittent but at times very large, it seems desirable to provide a receiving tank, into which the sewage flows first and from which it goes into the ejectors as shown in Figs. 22 and 23.

The **sewage-lifting plant** requires a pit in which the ejectors stand, one or preferably two air compressors and a storage tank for compressed air. The air compressors may be operated by steam or by electric power, and they may be belt-driven or direct-acting. The air pressure provided to lift the sewage is usually about 40 pounds, but it may be compressed to a higher pressure in the storage tank, in which case a pressure-reducing valve should be placed on the air pipe. In practice it is found that a pressure of two pounds is required for every foot of vertical lift.

The sewage tanks may also be arranged to operate by hand, but in that case they should be built of somewhat larger dimensions. The essential feature of automatic plants is the air valve, which should operate positively, quickly and quietly.

Fig. 15 shows a Shone sewage ejector in section, and Figs. 16 and 17 show the manner in which ejectors are fitted up in duplicate.

A plan showing the usual arrangement of the sewers, drains, location of ejectors, etc., is given in Fig. 18. It is slightly modified from a plan accompanying a description of the Shone system as

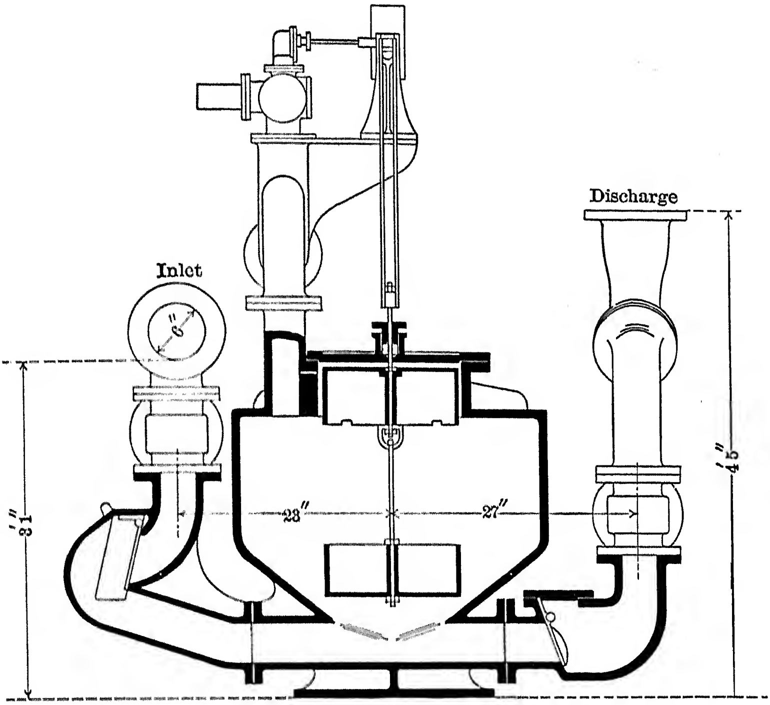


FIG. 15. Section of Shone Sewage Ejector.

applied to city buildings. For the sake of simplicity, only the sanitary sewers, surface drains, blow-offs from boilers, and a few drips leading into the surface basins are shown, but this is sufficient to indicate the principles involved. The following is an abstract of the description:

"In buildings in cities the ejectors are usually located in some central position, and the compressing machinery in the engine room or wherever convenient. It is preferable to have the latter placed where it can be seen by the engineers-in-charge while they go about their duties, as the normal action of the compressing machinery is a sure index of the like action on the part of the ejectors themselves.

"The ejectors are placed at such a depth that an ample fall can be given to all sewers and drains.

"The sanitary sewers are carried directly to the ejectors. Clean-outs provided with air-tight screw plugs are placed in these sewers at regular intervals. The manholes shown do not connect with the sewers themselves, but are merely to give access to these rodding holes.

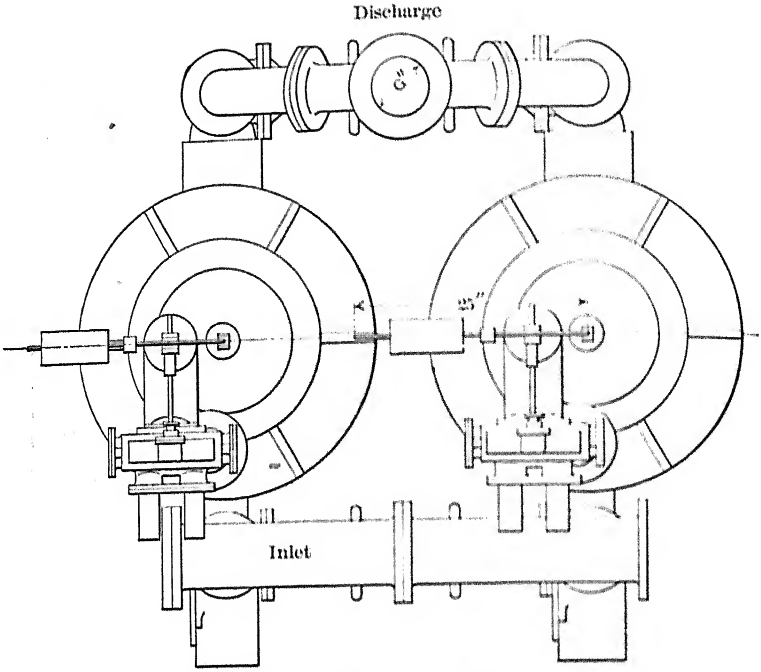
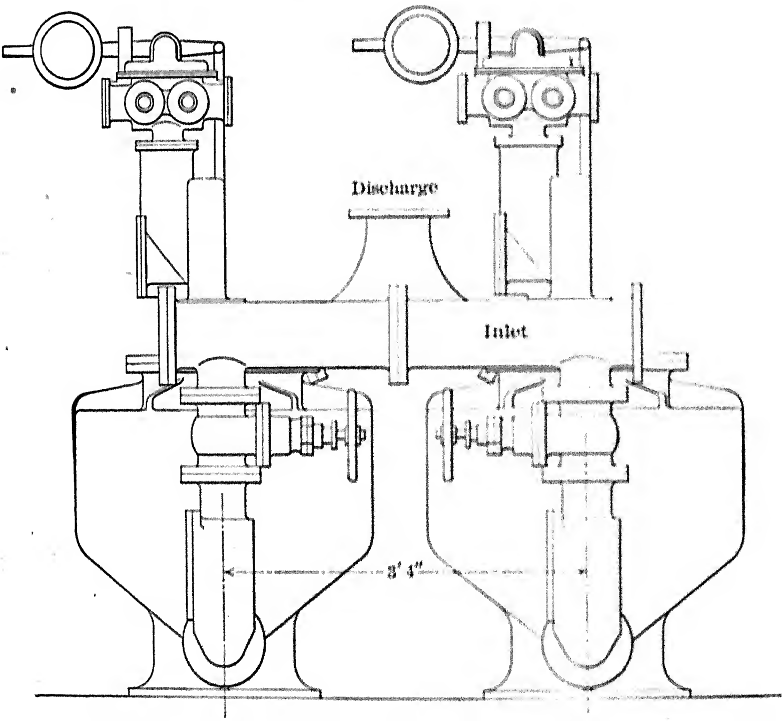


FIG. 16. Plan of Shone Sewage Ejectors.



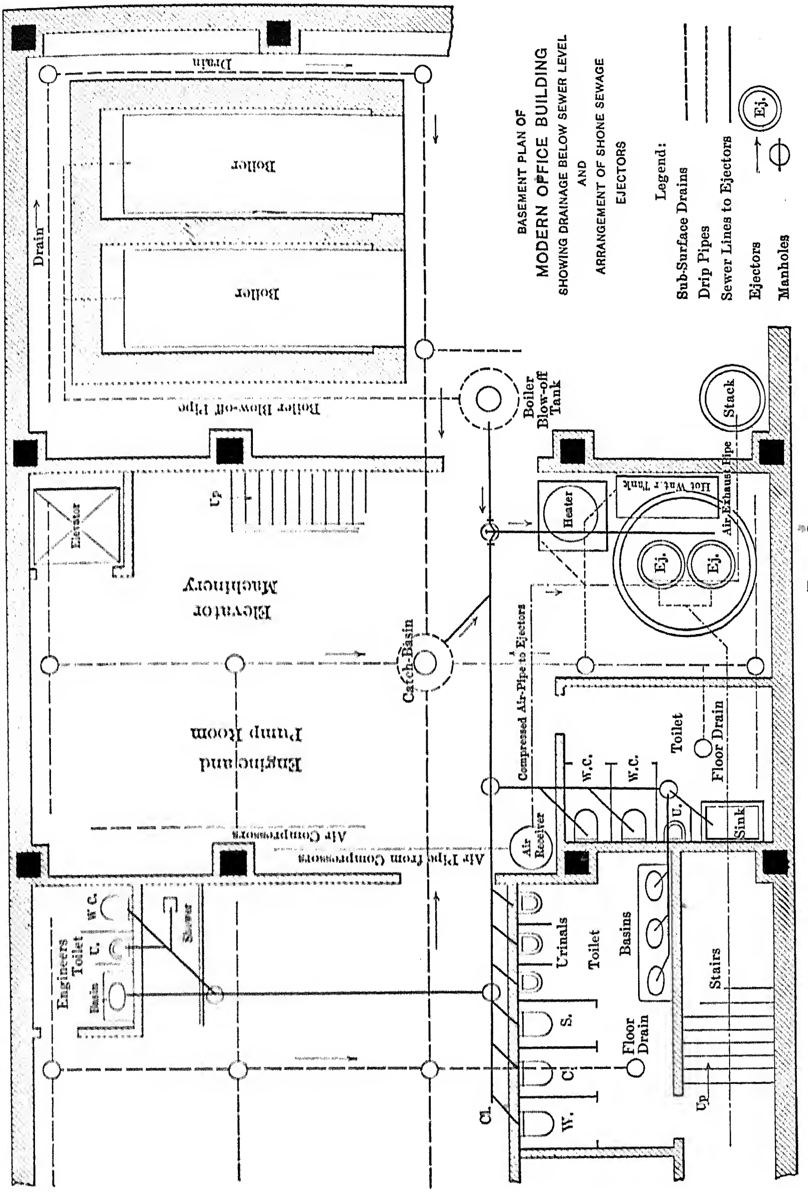

BASEMENT PLAN OF
MODERN OFFICE BUILDING
SHOWING DRAINAGE BELOW SEWER LEVEL
AND
ARRANGEMENT OF SHONE SEWAGE
EJECTORS
Legend:
Sub-Surface Drains
Drip Pipes
Sewer Lines to Ejectors
Ejectors
Manholes
Ej.
Drain
Boiler
Boiler
Boiler Blow-off Pipe
Boiler Blow-off Tank
Stack
Up
Elevator
Elevator Machinery
Hot Wat.r Tank
Heater
Air Exhaust Pipe
Ej.
Ej.
Catch-Basin
Compressed Air-Pipe to Ejectors
Engine and Pump Room
Air Compressors
Air Pipe from Compressors
Air Receiver
W.C.
W.C.
Toilet
Floor Drain
U.
Sink
Engineers Toilet
W.C.
U.
Basin
Shower
Urinals
Toilet
Basins
Stairs
S.
Floor Drain
Cl.
W.
Cl.
Up

FIG. 18.

"The surface drains are not continuous, but run into and out of the surface basins. There is no objection to this from a sanitary point of view, as the contents of these drains are innocuous, but the surface basins nevertheless may be, and frequently are, fitted with covers which are practically air-tight. The surface drains all converge to a catch-basin in the neighborhood of the ejectors, which communicates with the main sanitary sewer by means of one connection fitted with a trap and back-water valve. The blow-off basin likewise communicates with the main sanitary sewer in the same manner.

"The sanitary system is usually kept distinct from all others, but all the liquid wastes of the building of whatever description (excepting such as originate at an elevation sufficient to enable them to flow off by gravitation with certainty at all times, no matter what conditions may prevail in the street sewer) should be led to the ejectors, whether it be thought necessary to collect them into distinct systems or not.

"The discharge pipe from the ejectors can be led up to and along the basement ceiling and down to the street sewer, but it is preferable to lay it under the basement floor to the curb wall and from there up into the street sewer. It should be run independently of all others, as in case of any obstruction in it or the street sewer the ejectors would be liable to force the sewage back and up any pipes that might be connected to it.

"The air-pressure and air-exhaust pipes have merely to be run in the most convenient manner, and require no special description. The latter, however, which is for the purpose of providing a means whereby the exhaust air can escape to the outside of the building, need seldom to be run the whole way independently, as it can generally be connected to a flue from the boilers or to some vapor pipe or ventilating duct.

"Whenever it is possible to spare the room, ejector chambers should be left open, or at least partially so, and surrounded by a coping and railing. The object of this is to allow the ejectors to be seen, as there is no reason why they should not be kept as clean and be well taken care of as any other class of machinery, and this is far more likely to be the case when they are visible than if covered up and out of sight. If absolutely necessary, however, the chamber can be entirely covered and merely an entrance left, which can be closed with an ordinary manhole cover.

"Ejector chambers are usually circular in plan and they can be built in a variety of ways, but they are generally constructed either of brick in cement or of tank steel. The latter form is used where the ground is bad or where there is much water to contend with during construction, as unless the conditions are favorable great care is required in the construction of brick chambers in order to obtain water-tight work."

There are several other similar devices which require brief mention. One is the **Ellis ejector** or sewage lift (Fig. 19), the other the **Ansonia sewage ejector** (Fig. 24). Both of these appliances may be operated either by means of compressed air or by steam,

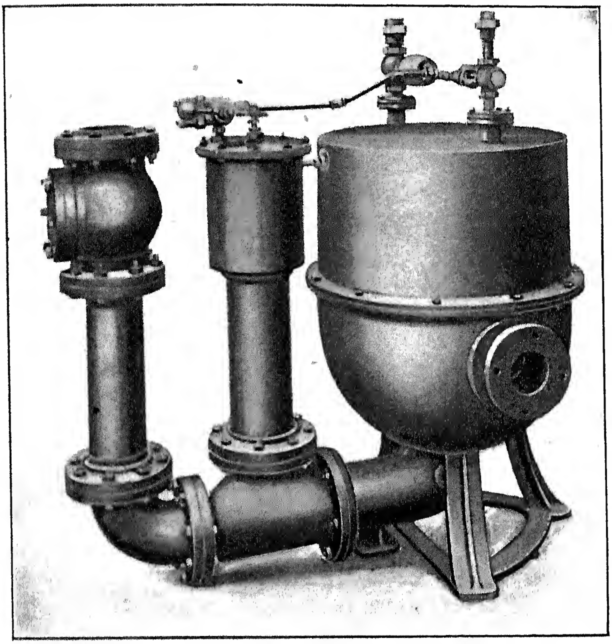


FIG. 19. View of Ellis Sewage Lift.

and they are also made as combination apparatus for both steam and air.

My personal preference is for a compressed-air apparatus. I believe the steam ejectors to be more or less wasteful of steam; moreover, a discharge of steam into the street sewers, which cannot be wholly avoided, is not to be advised, and in some cities it is very properly prohibited by rules of the sewer department. The hot steam mingling with the sewage and excrementitious matter is also liable to cause bad odors, though, of course, with a tight apparatus these would not be noticeable inside of a building. The compressed-air discharge is also preferable because it gives a full waterway in the discharge pipe. The very best kind of check valves

should be used with these apparatus. These and the automatic air valves are liable at times to give some trouble, but there are no other moving parts, and herein consists one of the advantages of sewage lifts.

Both the Ellis and the Ansonia sewage lifts follow closely the idea of the Shone apparatus as regards the use of compressed air, and they differ from it chiefly in the construction of the air valve used, also in the fact that the receivers are usually of wrought iron instead of cast iron.

In Figs. 20 and 21 I show in plan and elevation an installation of four Ellis sewage ejectors as put in under my direction for the St. Regis Hotel in New York City. These smaller tanks replaced one large sewage tank which failed to operate properly at all times.

Figs. 22 and 23 show in plan and elevation another plant designed by me for an addition to the same hotel. The receiving tank, mentioned heretofore, is a feature of this installation which has worked very successfully for several years.

Fig. 24 shows an Ansonia ejector installation erected from my plans for a municipal building in New York City. This is a combination compressed air and steam ejector plant.

There is another sewage-lifting system which is different in principle from the Shone system, and which is called, after its original inventor in England, the **"Adams" sewage lift.** It has been modified somewhat by Mr. Priestman, C. E., of Philadelphia, and is made by Merritt & Co. of that city. This device operates on a different principle, and differs from the three others in not requiring any air compressors and air-storage tanks. Fig. 25 shows the chief elements of the system, which is composed of several tanks. The air pressure necessary to lift the sewage is obtained by the head of water from a tank on a higher level, which discharges by means of a siphon into a lower tank and compresses the air. The system is somewhat more complicated than the others described, but it also has some advantages. Where, however, the water required to operate the air tank has to be pumped, it does not appear to me that the system has any advantages over the direct pumping of the sewage by centrifugal pumps.

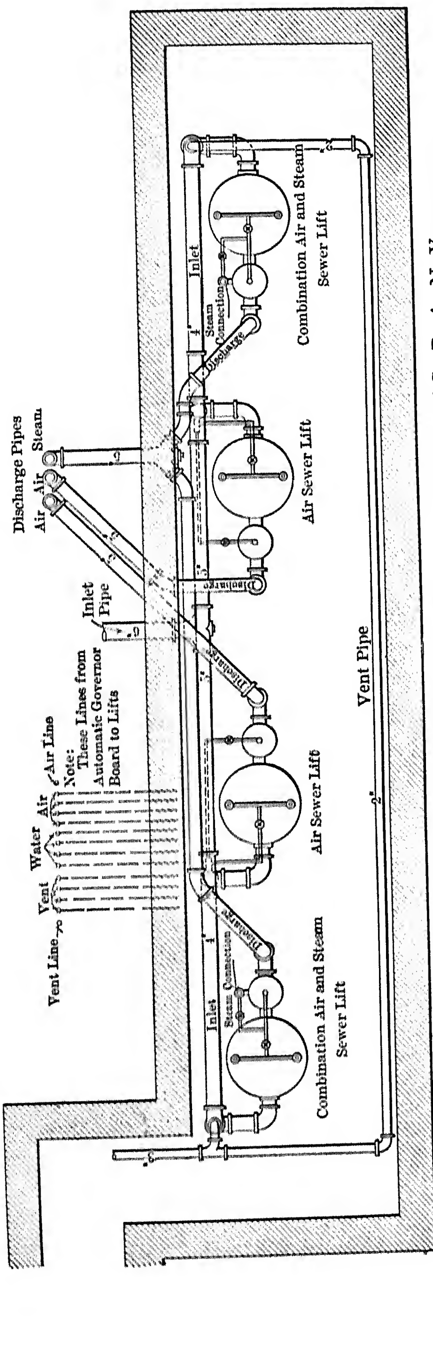


FIG. 20. Plan Showing Arrangement of Four Ellis Sewage Lifts at Hotel St. Regis, N. Y.

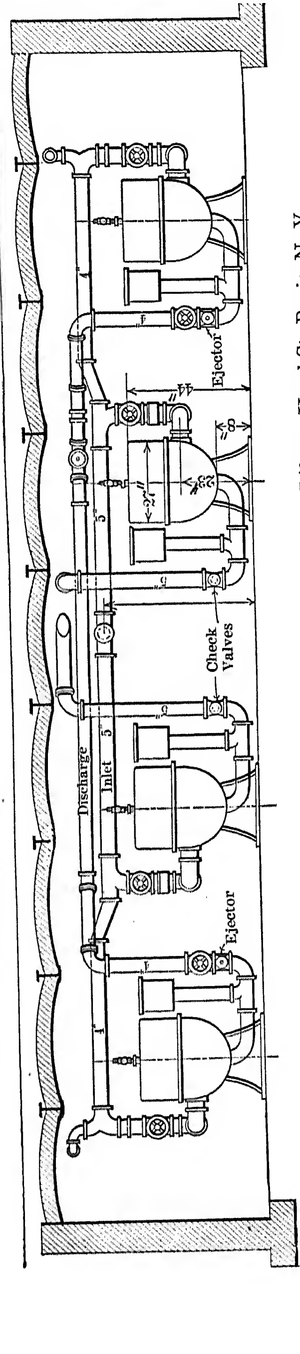


FIG 21. Elevation Showing Arrangement of Four Ellis Sewage Lifts at Hotel St. Regis, N. Y.

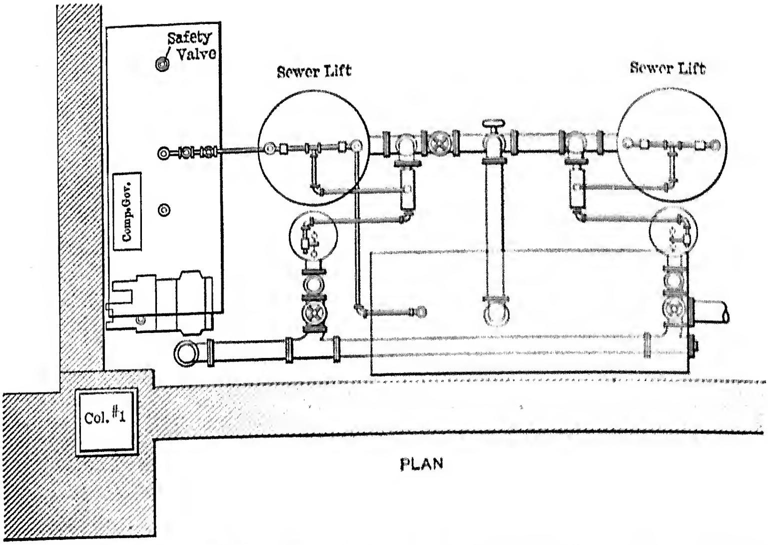


FIG. 22. Showing Arrangement of Ansonia Sewage Lift at Addition to Hotel St. Regis.

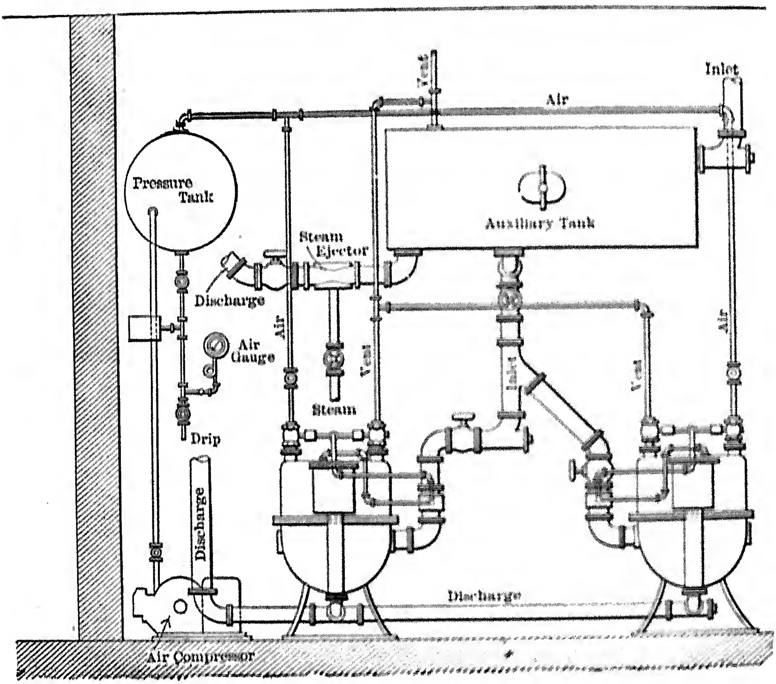


FIG. 23. Elevation of Sewage Lifts Shown in Plan in Fig. 22.

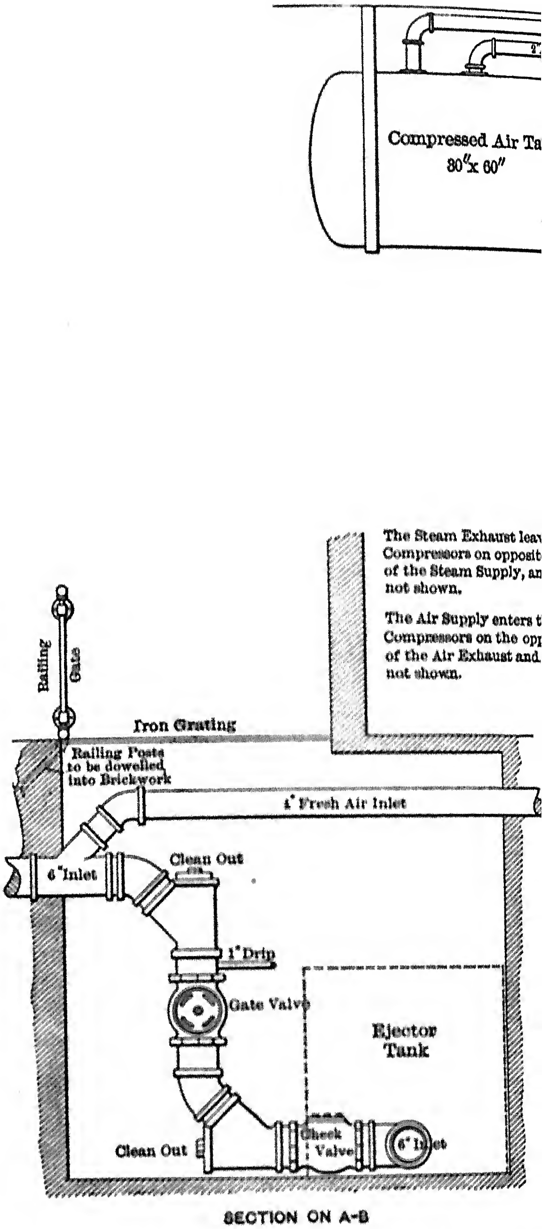
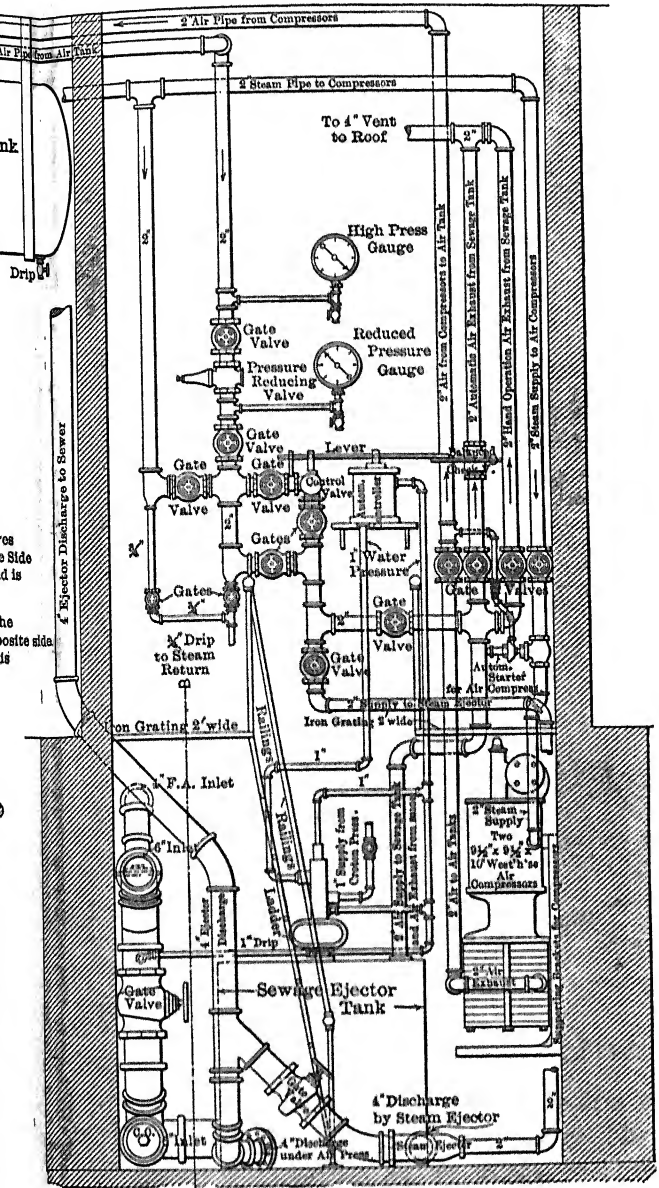


Fig. 24. Arrangement of Ansoni



ELEVATION

a Sewage Ejector at Police Building, New York City.

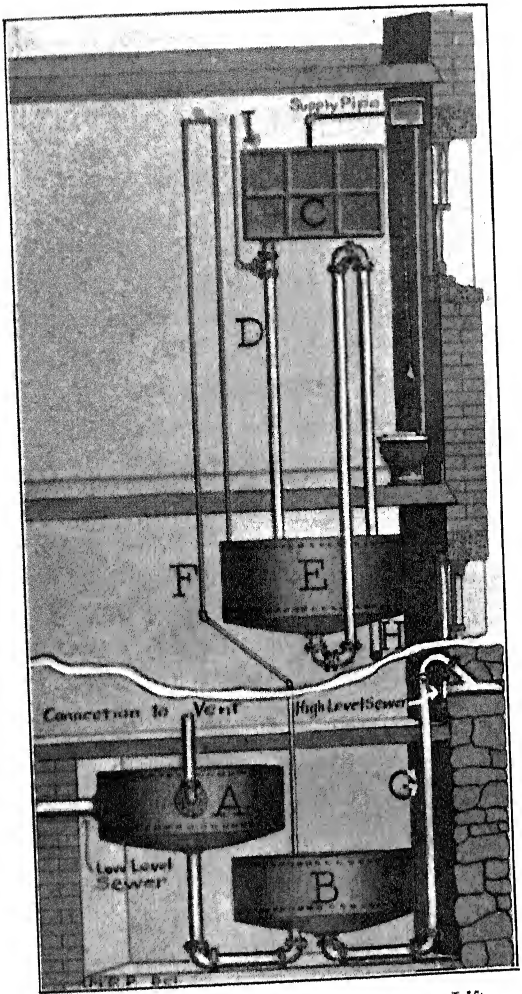


FIG. 25. Arrangement of Adams Sewage Lift.

TRAPPING THE FIXTURES.

An essential requirement of a system of house drainage is the safe *trapping of the plumbing fixtures.* By this is meant the application of a suitable device in the waste outlet pipe of the fixture, intended to interpose a barrier against sewer air from the soil or waste pipe, and which, while it permits the waste water and other liquid or semi-liquid matter to flow off, retains sufficient water, after the flow has ceased, to form a water seal.

The rule is that every plumbing fixture should be separately trapped by a water-sealed trap placed as close to the fixture as possible. The entire system of trapping of the fixtures should be so arranged that the discharge from any fixture does not pass through more than one trap before reaching the soil pipe or the house drain. All traps should be kept exposed to view and accessible for inspection and repairs. The clean-outs on traps should preferably be located below the water level of the trap.

In order to be self-cleansing, traps should not be larger than the branch waste pipes of the fixtures. The simplest form of trap consists of a pipe bent in the shape of the letter P or S, and holding a depth of water seal varying from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches.

Atmospheric and other influences tend to destroy this water seal. An abnormal pressure in a soil or waste pipe may force the seal by back pressure; sudden and quick discharges of water through a soil pipe create a suction behind the water column, and exert a siphoning effect on the traps — so-called siphonage; during prolonged disuse of a fixture the water seal is destroyed by evaporation, and finally a trap seal may become ineffective owing to loss of water through capillary attraction.

Objectionable Forms of Traps. — Mechanical traps with floating balls, flap valves, checks, heavy balls, etc., have been devised as an additional protection, but are only partly effective, and usually become more or less foul in prolonged use. Some of the water-seal traps, like the D-trap, the bottle trap, the round trap or drum trap, are open to the same objection. Traps with inside partitions cannot be relied upon, as there may be sand holes or flaws in them.

Back-Venting of Traps. — The common S or P traps are perhaps cleaner in use, but under certain conditions they are particularly liable to siphonage. To prevent this, special lines of vent or "*back-air*" *pipes* are attached near the upper bend of the trap and carried to the roof in the same manner as soil pipes, or they enter these above the highest fixtures. With fixtures located on several floors, this leads to a double pipe system, which increases the cost, complicates the system, nearly doubles the number of pipe joints and consequently the risk of leaks of sewer air, and establishes air currents over the water seal which have a tendency to destroy it, except where the fixtures are in daily use.

Where back-air pipes are used, the following rules should be observed: All offsets in vent pipes should be made under an angle of at least 45 degrees, and all vent lines should be dripped at the bottom into a soil or waste pipe or into the drain, to prevent the accumulation of rust scales.

The branch vents to the fixture traps should be kept above the top of the fixtures and be connected as near the crown as possible, or preferably arranged as a continuous vent, except in the case of

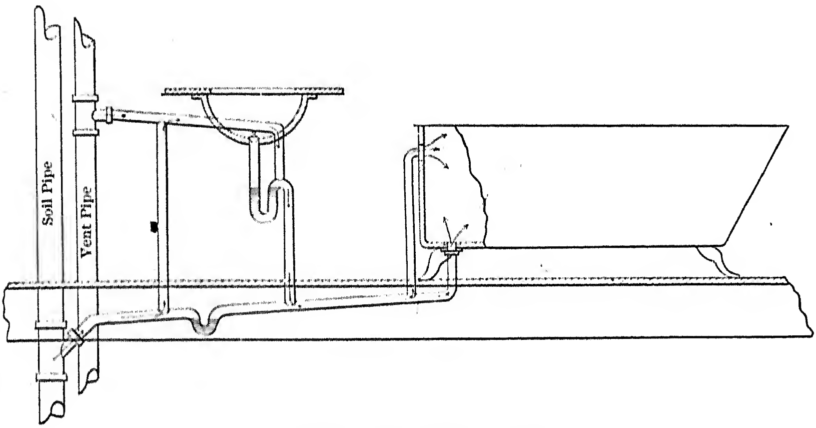


FIG. 26. Plumbing By-passes.

earthenware traps for water-closets and slop-sinks, which should be vented from the lead bend which is located under the floor and connects the closet outlet with the soil pipe.

The "back-air pipe" system offers opportunities for dangerous *by-passes*, or faulty connections between the back-air pipes and other pipes, whereby an open passage is created for gases from the soil or waste pipe system into the rooms of a house. The illustrations Figs. 26 to 29 show some of the more commonly occurring by-passes, and require no further explanation, as the cuts tell their own story.

Non-siphoning Traps. — There are a number of water-sealed traps, called *non-siphoning traps*, like the Sanitas, Puro, King, Ideal, Hydric and the Sanito, which are shaped with a view of retaining a water seal when siphonic action takes place in the system, and their seal is, as a rule, made deeper than usual.

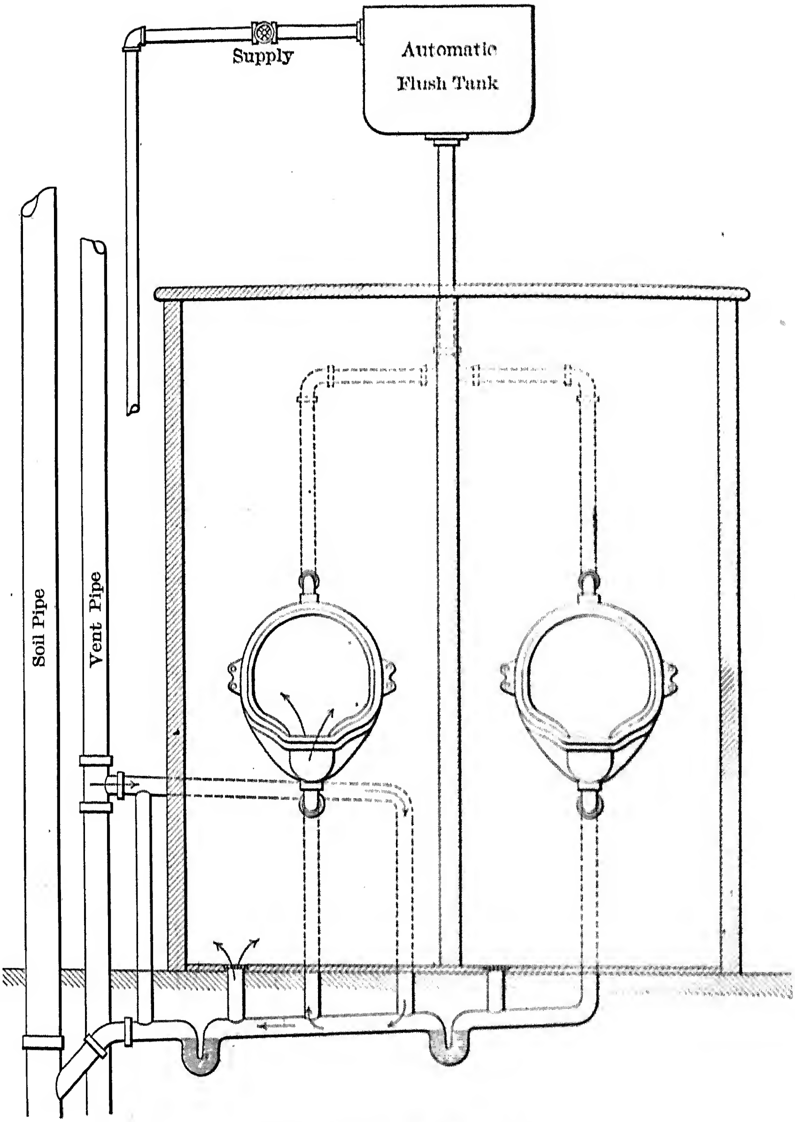


FIG. 27. Plumbing By-passes.

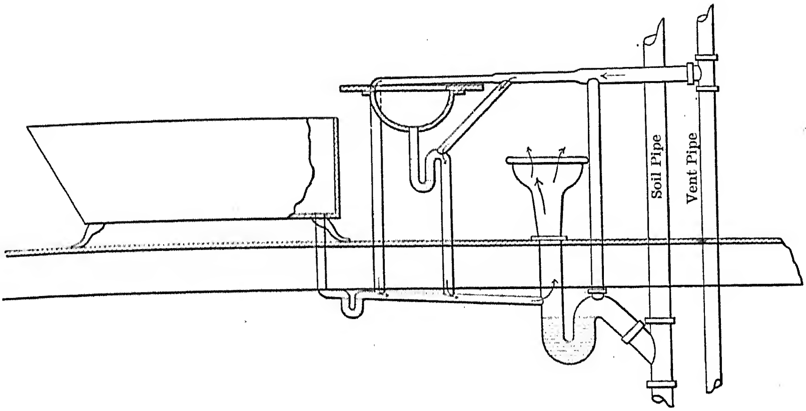


FIG. 28. Plumbing By-passes.

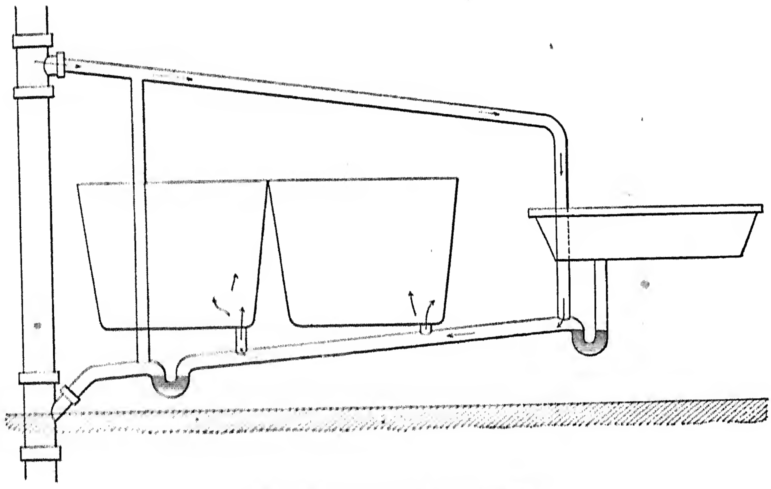


FIG. 29. Plumbing By-passes.

Where non-siphoning traps and water-closets with a deep water seal are used, the special back-air pipes may be dispensed with, provided the fixtures are located close to a ventilated soil or waste line. In my practice I consider a run of five feet as the largest allowable length for the use of such traps without a vent continuation of the waste pipe. Long branches should be vented, either by interconnection with vent stacks or by extension to the roof, but if so arranged, the branch trap vents may be omitted.

This **improved system** is far superior to the one commonly required by Building Department rules or regulations. The present tendency involves unquestionably too much complication. A comparison between the two methods shows clearly the superiority of the simpler system, which is now advocated by some of the best authorities. Hence the municipal plumbing regulations of cities should be revised so as to make it optional with an architect or the owner which system to adopt.

The subject of back-airing traps is of so much importance that it will be referred to again in Chapter III.

The matter of **trap venting** and the use of non-siphoning traps are also discussed at considerable length in the author's book "Sanitary Engineering of Buildings." In the chapter entitled "Simplified Plumbing Methods" he made suggestions for a modified, simpler and at the same time *safer* plumbing system.

Commenting on these suggestions, the *American Architect*, then one of the leading architectural papers in the United States, wrote as follows:

> "It is always a pleasure to architects to read what Mr. William Paul Gerhard writes on matters of sanitation. Alone, almost, among those who treat of such subjects in these days, he writes like an engineer familiar with all methods and appliances in use, judging them with the aid of long experience and thorough theoretical knowledge, and dispassionately choosing what he believes to be the best thing attainable, without any reservations, exaggerations and misrepresentations on behalf of pet theories, or the private interest of himself or his friends. For this reason it is particularly noteworthy that he should have come out against the system of indiscriminate trap venting which is now imposed by the law on architects and plumbers in most of our large cities.
>
> "It has long been understood that Mr. Gerhard did not favor indiscriminate trap venting, but, like the other professional men concerned with building matters, he has found it best to sacrifice his private opinions and submit quietly to the law, and it is only a growing conviction of danger to health involved in the multiplication of pipes and joints which the law renders compulsory, that can have led him to protest publicly against the enforced use of the present 'antiquated, costly and in a good many respects unsafe methods.' The reasons which he gives for this protest are convincing enough to all those who have to do with building.
>
> "As architects know, in the execution of a complicated piece of plumbing work under the present law it is almost impossible to avoid such

intercommunication of waste pipes and vent pipes as to form here and there a 'by-pass,' or in other words, an open conduit for leading sewer air from the waste pipes directly into the rooms around the traps. Many a plumbing plan is rejected by Boards of Health because it provides, of course unintentionally, for such a by-pass at the outset, and many more systems properly planned are rendered dangerous by the carelessness of workmen in making connections. The only real reason that has ever existed for back-venting traps was to prevent them from being siphoned out by the suction from a main waste pipe discharging water enough nearly to fill it. Twenty years ago, when S-traps were in common use, this was a valid reason; but now, when non-siphoning traps are almost universally employed, there is no advantage in the venting system which cannot be better secured by using a five-inch soil pipe in place of a four-inch, carrying up the longer branches to the roof, and placing modern traps under the fixtures."

Plumbing Fixtures.

A detailed discussion of **plumbing fixtures** is reserved for Chapter II, hence only the more important ones are briefly described here. All plumbing fixtures should be provided with a sufficient supply of water to maintain them in a cleanly and sanitary condition. Fixtures of public toilet rooms require periodical inspection and constant care in maintenance.

Location of Plumbing Fixtures. — The scattering of plumbing appliances over a house is no longer practiced; the work is confined to the well-lighted and well-ventilated bath and toilet rooms, to the butler's pantry, the kitchen and the laundry. Where possible, the water-closets should be placed in compartments separate from the bath rooms, but having direct access to light and air, or ventilated mechanically and lighted electrically.

All **fixtures should be quick-emptying** in order to flush out the traps and their waste pipes. In case of water-closets, urinals and slop-sinks the flushing is best accomplished by means of flushing cisterns.

Water-Closets. — The most important appliance in houses, from a sanitary point of view, is the water-closet. It usually consists of a metal or porcelain bowl with flushing rim set on an impervious floor slab, provided with hardwood seat and with flushing cistern or else special flushing valve, with flush pipe, and with lead bend

connection to the iron soil pipe. Numerous types of water-closets have been devised, many of which after a brief period of trial have been again abandoned. Of the older types the pan closet was the one to hold out the longest, notwithstanding the universal condemnation which it received from sanitarians. At the present writing the pan, valve, and plunger closets have almost entirely disappeared from the market. Cheap washout closets and a few of the same type and of a good make are still in demand, although they are not free from defects.

In well-appointed modern bath and toilet rooms the all-porcelain or vitreous-ware siphon and siphon-jet closets are preferred. For institutions, schools and for servants' closets the pedestal washdown closets make a thoroughly sanitary fixture, particularly those having a deep water seal. In some situations a flushing-rim hopper closet works satisfactorily. Where rough usage is to be expected, as in factories, stables and public comfort stations, closets of enameled iron may be used.

Flushing of Water-Closets, etc. — Water-closets should have earthenware bowls provided with **flushing rims**; the so-called pipe-wash bowls and also the hopper, pan, valve and plunger closets should not be used. Water-closets and urinals should always be flushed from separate cisterns on each floor, the water from which is used for no other purpose. The special devices known as flushometer valves are referred to in Chapters V and VI.

Wash Basins. — In modern plumbing, **basins** are "set" or stationary fixtures, consisting of an earthen or marble slab, with bowl attached to it, or of enameled iron with metal or marble supports, and with waste and supply pipes, faucets, traps and other appurtenances. Wash basins are manufactured in a great variety of patterns and types. Those with waste outlet closed by a metal plug held suspended by a chain or rubber cablet, and those having a standpipe overflow or else a metal plug operated by a lever, are much better than the bowls with secret waste valves or the tip-up basins.

Bath Tubs. — The **bath-tub** fixtures are either of enameled iron or of solid porcelain; copper tubs are rarely used nowadays. Bath tubs are set on the floor, or raised from it on legs or other forms of support, or finally they are sunk into the floor. The latter arrangement requires special provision in the floor construction and is not,

therefore, much in use. In England, bath tubs are designated as "slipper baths," which originally were bathing tubs covered at one end and thus resembling a slipper in shape.*

In hospitals for insane and also in people's bath houses, rain, douche or **spray baths** are substituted for the tub baths, being considered more sanitary and economical. There are a number of forms for spray, douche and shower baths, also large combination needle and spray baths, and several types of baths for the bathing of parts of the body.

Urinals. — **Urinal** fixtures have been much improved in recent years, and a very good pattern for single urinal stalls consists of a flushing-rim bowl made to hold water, and flushed from a special cistern or else by mean of a flushing valve. In public places, such as railroad stations and the like, also for factories and schools, continuous troughs of enameled iron or of stoneware with automatic intermittent flush, or else solid porcelain urinals in niche form, are used.

Washtubs. — The former **washtubs** of wood have been superseded by soapstone, slate and artificial cement tubs for the cheaper class of dwelling-houses, and by white or yellow solid glazed roll-rim earthenware tubs for the more expensive residences, as well as for hotels and institutions.

Slop-Sinks. — **Slop-sinks** are sinks made in form deeper than the ordinary sinks, and provided with larger waste outlet. They are manufactured either of enameled iron or of heavy fire clay, and are sometimes provided with a top flushing rim supplied from a special flushing cistern.

Sinks. — Sinks are fixtures intended for pouring out kitchen dish and wash water, or they are meant to serve as tray to catch drippings where water is drawn in pails or in jars, as in housemaids' closets or in conservatories; they also serve to receive the drippings from refrigerators and ice boxes. In kitchen, pantries and sculleries sinks are used for the washing of dishes, pots, kettles and pans. They are manufactured in painted, galvanized and enameled iron, in copper, soapstone, slate and in white and yellow solid porcelain ware. The latter sinks are by far the best from a sanitary point of view, and recent improved methods of manufacture at American

* See illustration in Gerhard's "Modern Baths and Bath Houses," 1908.

potteries have enabled the makers to reduce their price considerably. Wooden sinks should not be used.

Grease Traps. — In kitchens of large hotels and institutions the grease from dishwashing and from cooking operations is intercepted in **grease traps,** in order to prevent stoppages in the waste pipes and drains. Some forms of grease traps are attached directly under the kitchen or pantry sink; in other cases they are placed outside of the building, on the line of the kitchen drain.

Exposed or Open Plumbing Work. — A feature of modern plumbing work is the accessibility of all its parts. Wooden enclosures around water-closets, sinks and other fixtures are no longer used, and these fixtures are always set in an open manner. Pipes and traps remaining exposed are rendered unobjectionable to sight or even attractive by painting or bronzing, and in passing it may be stated that it is a popular fallacy to suppose that the nickel plating of exposed pipes and fittings is essential for sanitary work.

Floor Joints. — All earthenware traps should be connected with the lead bends by heavy brass floor plates, which must be soldered to the lead bend and bolted to the trap flange, the joint between the floor plate and the trap being made gas-tight with some plastic substance or asbestos packing. An improved screw joint for water-closets is shown in Fig. 86, Chapter II.

Safe Wastes. — Safe wastes and **refrigerator waste pipes** should not be connected with any part of the plumbing system, but they should discharge over a water-supplied sink. The refrigerator waste pipes and all safe wastes should be provided with flap valves at their lower ends.

Overflow Pipes. — If fixtures have overflow pipes, these should always be connected on the inlet or house side of the traps.

Water Supply.

Essential Parts of a General Water-supply System. — A complete water-supply system, whether for a city, town, or a group of buildings, comprises the following parts:

1. Means and structures for the **collection** of water at the source of supply if a spring or well, or intakes if the supply is to come from a stream or lake;

2. Means for its **purification** in settling basins or in large filters;

3. Means for **conducting** it from its source to

4. Its **storage** in receiving reservoirs, elevated tanks or standpipes;

5. Means for its **distribution** through smaller distributing reservoirs and through a system of pipe conduits, comprising mains, laterals, service and house-supply pipes with valves, hydrants, meters and faucets. Quite often it includes

6. A **water-pumping plant,** comprising buildings with pumping machinery, steam boilers, or electric motors, or gas, gasoline or oil engines connected with pumps, for the lifting of the water from its source or the intake to the place of storage.

Broadly speaking, two systems of water supply may be distinguished, namely, the **gravity** and the **pumping system.**

Gravity Supply System. — In a gravity water-supply system the intake or the source of supply is located at such an elevation above the buildings to be supplied that gravity alone suffices as a motive force to bring the water from the storage reservoir to the places of consumption.

Pumping System. — In a pumping system the water intake or the source of supply is located so low as to require some form of water-lifting machinery in order to make the water available for use. The water-pumping system is called (*a*) **direct** when the water is pumped directly into the network of distributing mains, and it is called (*b*) **indirect** when the pumps lift the water first into a reservoir, standpipe or pressure tank, from which the distribution takes place by gravity. A third system might be called (*c*) the **direct-indirect,** the water being pumped directly into mains, but the excess of water pumped over that drawn or used goes into reservoirs or into standpipes, and is used to equalize the flow or to make up for hours of excessive consumption, or to render service during repairs to the pumping machinery, or during the night, when the operation of the pumps stops.

A gravity water-supply system is cheaper as regards operating expenses than a direct-pumping system. The latter is also more liable to interruption by accidents, and for this reason requires the provision of a duplicate set of pumps and generally of two pumping

mains. The indirect-pumping system is more economical in operation than the direct-pumping system.

Water-supply systems for larger communities and for groups of habitations make use chiefly of **reservoirs,** where the conditions are favorable for their use, whereas supply systems for individual buildings make use chiefly of **elevated tanks,** of **pressure tanks** and in some cases of **standpipes.**

Quantity of Water Required. — The quantity of water needed for domestic supply varies in different cities, and is much larger in the United States than in Europe. Whereas in England the standard **allowance** per day is 37 U. S. gallons, in the United States it is generally assumed that 60 gallons is a fair daily capacity allowance, which includes water for drinking, cooking, washing, bathing, laundry, stable, flushing of water-closets, and for ordinary manufacturing purposes.

The above theoretical allowance does not by any means agree with actual figures of **water consumption.** Water statistics necessarily vary somewhat from year to year, and tabular statistics, like statistical figures generally, are apt to be incorrect and sometimes misleading. Nevertheless, conservative engineers are all agreed that a large part of the daily water consumption is really **water waste,** and this is proven by a comparison of figures for cities in which the majority of services are metered with like figures in cities without water meters.

A careful study was made of this question some years ago by Mr. George S. Bailey, Superintendent of the Albany, N. Y., waterworks. According to his tabulated summary, the average daily per capita water consumption of 134 cities in the United States was 137 U. S. gallons; in 71 cities with less than 10 per cent of the water taps or service metered the average consumption was 153 gallons; in 18 cities with from 10 to 25 per cent taps metered it was 110 gallons; in 22 cities with from 25 to 50 per cent metered it was 104 gallons; and in 23 cities with over 50 per cent taps metered the consumption fell to 62 gallons. In other words, *the average consumption is 2.2 times as large as it should be.*

In Washington, D. C., where only few taps are metered, the consumption reached the high amount of 158 gallons in 1890 and of 185 in 1900; in New York, where about one-fifth of the taps are

metered, the consumption was 79 in 1890 and 116 in 1900; in Providence, R. I., which has about 75 per cent of the taps metered, the figures were 48 in 1890 and 54 in 1900; in Fall River, where 94 per cent of taps are metered, it was 36 gallons.

The highest rate of consumption was shown by the city of Allegheny, Pa. (with no meters), namely 238 gallons; Buffalo came next with 186 gallons, and Providence, R. I., and Fall River, Mass., showed the smallest average daily consumption. These figures and data are valuable because they prove beyond a doubt the beneficial effect of meters in checking waste and reducing water consumption.

The question of water consumption in large city buildings will be referred to again in Chapter VI.

Standpipes. — Waterworks standpipes are used principally in places where for lack of an elevated site or for other reasons it is impracticable to build a reservoir. They are constructed of wrought iron or of steel; they are anchored or bolted to a strong foundation, and are sometimes provided with guys to steady them against wind pressure.

A waterworks standpipe remains either exposed or else it is enclosed, generally with masonry, for one or more of the following reasons: to furnish protection in winter time against freezing; to shield it against wind pressure in exposed localities; or to give the structure an ornamental appearance.

Speaking of the disfigurement of the countryside everywhere "with gaunt top-heavy skeleton windmill and tank towers," a writer in *The American Architect* draws attention to "another and more obnoxious monstrosity that utilitarian engineers have imposed on the landscape and which calls urgently for redress, in a double sense, namely, the wrought-iron standpipe of the local water companies, which, standing on the highest elevation within the reach of economical pumping, forms a blot on the landscape which can be seen in every direction for miles around."

Sometimes such **standpipes** are **used** merely **as pressure regulators or water cushions,** in which case it is usual to place them close to the pumping station. Sometimes they are used to provide, in connection with water mains supplied by direct pumping, a storage of water sufficient for about one hour's fire consumption.

Elevated Tanks. — Where the storage of water is the chief object, and where the topography of the ground is such as not to afford a chance for the construction of a reservoir, **elevated tanks** of steel or wood, placed on tank towers of steel, wood or masonry, take

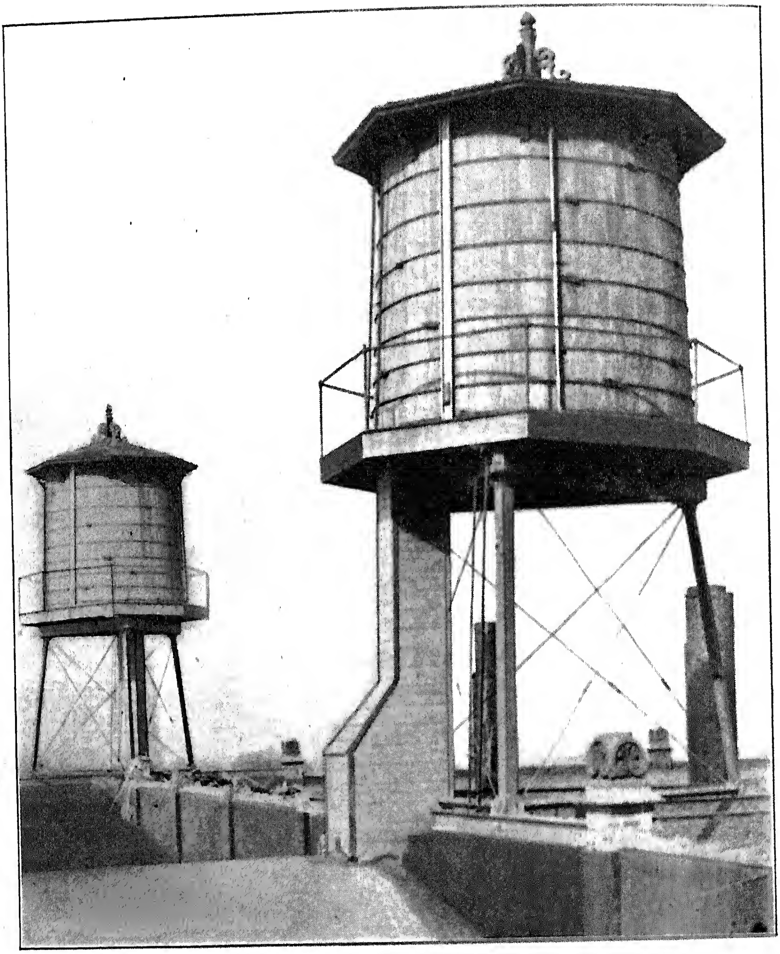


FIG. 30. View of Wooden Roof Tanks.

the place of standpipes. In city buildings such elevated tanks are placed on the high roofs of the buildings (see Fig. 30) or on special steel towers (Fig. 31). There are several objections to these so-called **roof tanks.** One is their heavy weight which must be car-

ried by the superstructure, another is their unsightliness, and still another is an important one from the sanitary point of view, for it is difficult to maintain the purity of the water stored in such tanks

FIG. 31. View of Wooden Tank on Steel Tower.

and they are liable to many kinds of contamination. In tenement-houses it has actually occurred that mischievous boys have used the tanks in summer time to take a bath. A recent editorial in *The Metal Worker* is to the point:

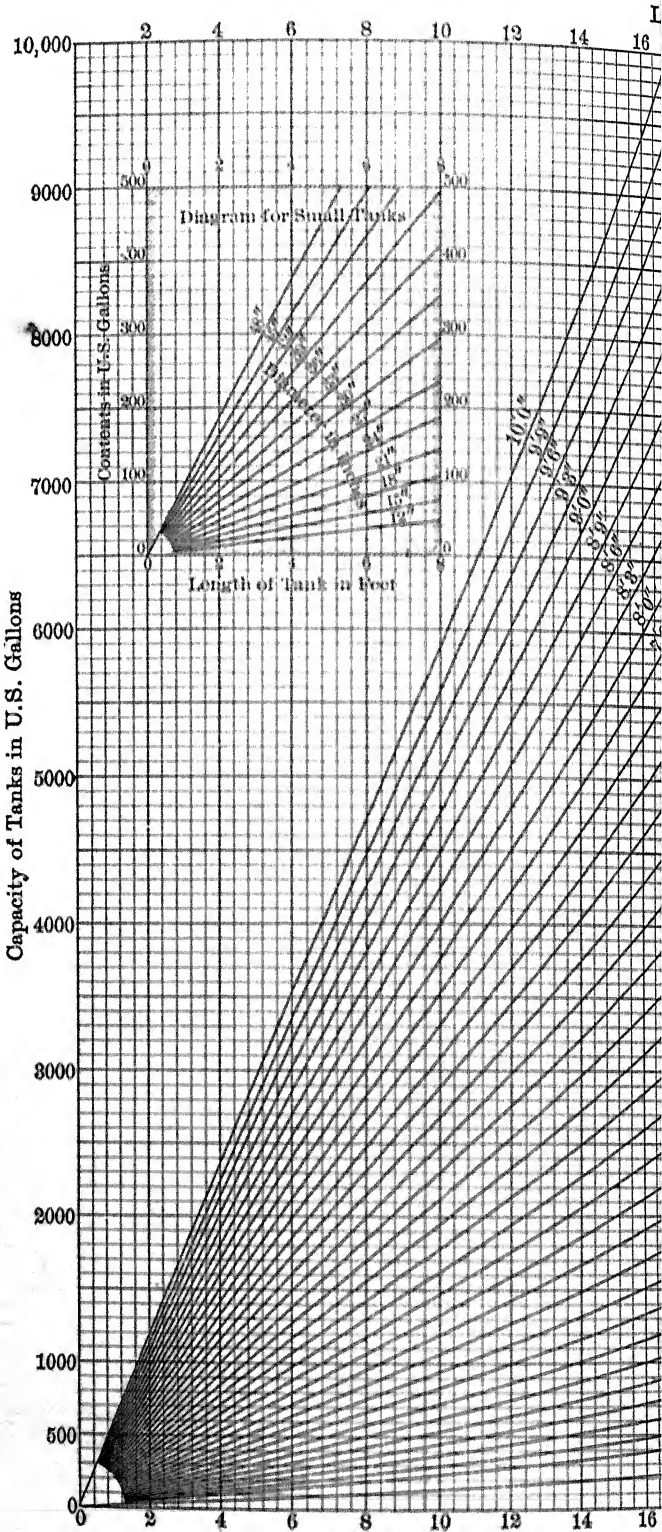
"The purity of the water supply has a more far-reaching effect upon the health of the public than the multitude is apt to realize. A step toward the protection of their health is taken in the movement to abolish the use of roof tanks for supplying the upper floors of buildings in large cities. Those who have devoted some time to an investigation of these tanks find that street dirt with whatever fæcal bacteria it may contain is frequently carried to the top of the building where roof tanks are used, and no small deposit of this dust is found in the bottom of the tanks. . . . In order to avoid both the dust and the misuse of the house tanks, the substitution of a pressure tank located in the basement of the buildings is advocated. This sort of tank has another recommendation in that it does not subject the building to the strain of supporting a tremendous weight, which in some instances has led to the tank falling through the building, when the framework gave way, and doing extensive damage as well as risking life."

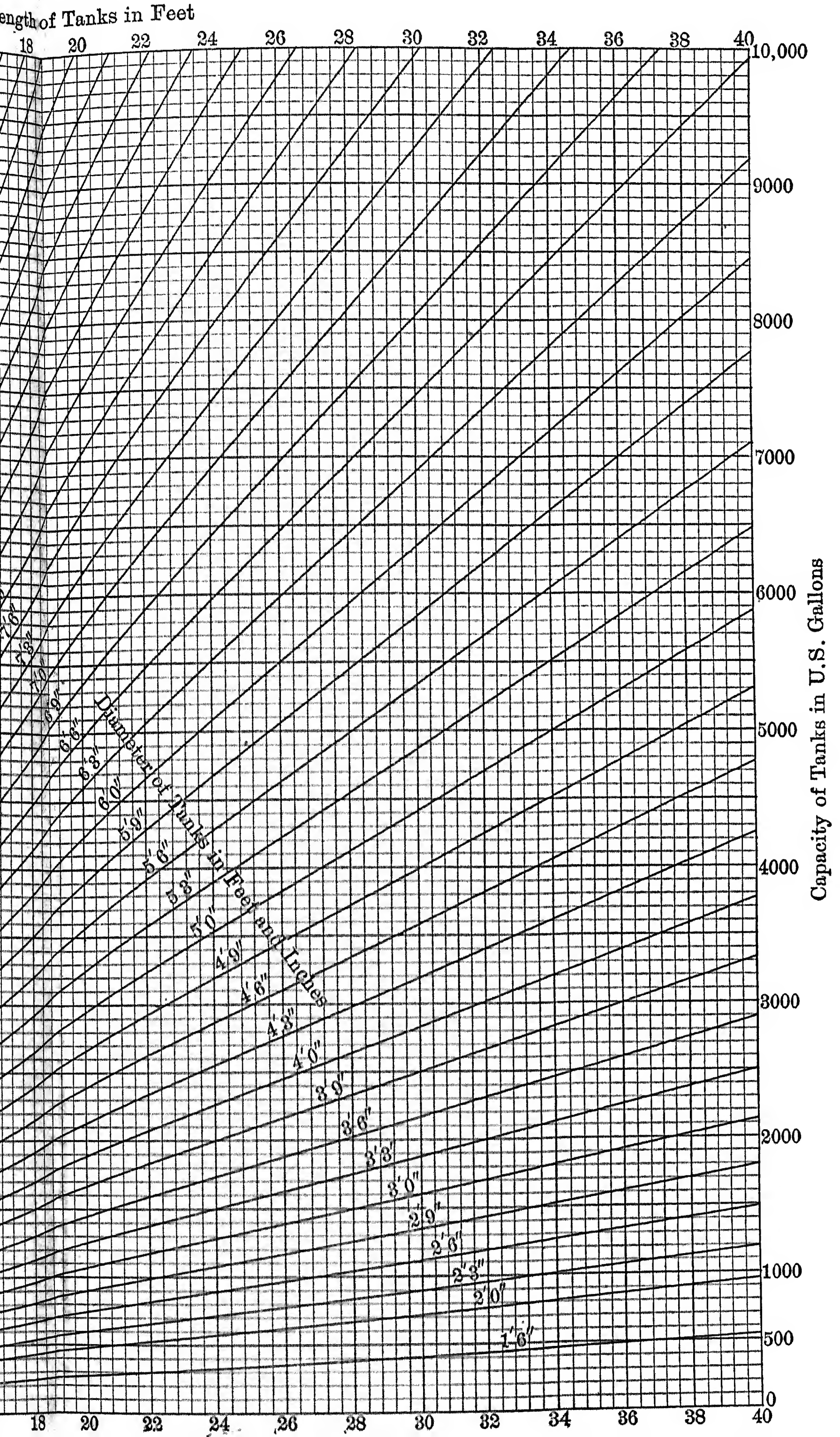
Pressure-tank Systems. — I shall dwell upon the subject of pressure tanks at some length, for two reasons: first, I find a good deal of ignorance or misconception regarding the use of **pressure tanks,** and second, it is my belief that they are destined to play an important rôle in future water-supply systems.

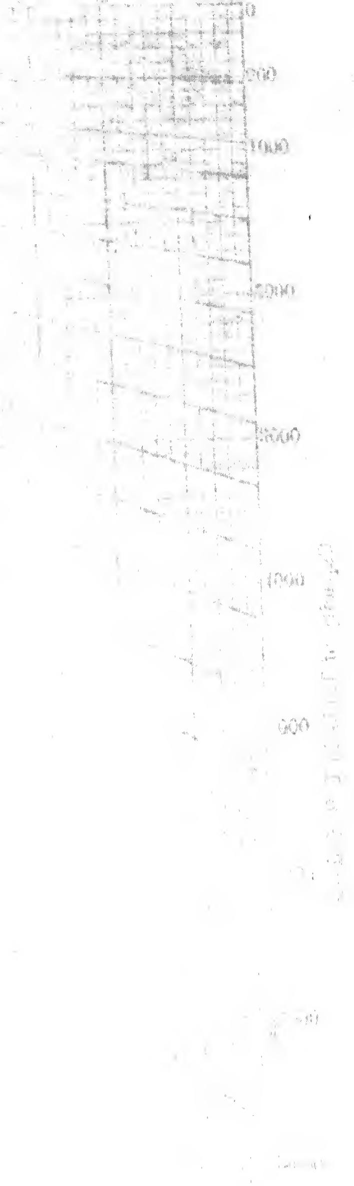
The majority of engineers are agreed that the direct-pumping system, without the use of a service reservoir or of a standpipe, is an inferior system, for it necessitates the continuous running of the pumps, and owing to the fluctuations in the water consumption and in the draught on the mains, the pumping machinery is subjected at times to severe shocks and strains.

Various means have been resorted to by waterworks engineers to equalize the pressure and to cause the pumps to run more steadily and uniformly, such as the use of accumulators or of large air chambers, but neither of these possesses the advantage of furnishing a sufficient storage capacity. Standpipes are not in all cases efficient substitutes for storage reservoirs, for though they equalize the pressure, it is obvious that all water held by them below the level of the normal head is not supplied to the consumers under advantageous conditions of pressure.

Closed or pressure tanks for the combined storage of water and air have often been used. They answer the purpose in cases where the pumping plant can be kept running most of the time, but where this is not the case they are less satisfactory, because as the water


Capacity of Tanks in U.S. Gallons
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
500
0
2
4
6
8
10
12
14
16
Diagram for Small Tanks
Contents in U.S. Gallons
Length of Tank in Feet
10'0"
9'9"
9'6"
9'3"
9'0"
8'9"
8'6"
8'3"
8'0"


Length of Tanks in Feet
Capacity of Tanks in U.S. Gallons
Diameter of Tanks in Feet and Inches
18
20
22
24
26
28
30
32
34
36
38
40
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
500
0
7'6"
7'3"
7'0"
6'9"
6'6"
6'3"
6'0"
5'9"
5'6"
5'3"
5'0"
4'9"
4'6"
4'3"
4'0"
3'9"
3'6"
3'3"
3'0"
2'9"
2'6"
2'3"
2'0"
1'6"



500
1000
2000

is drawn from the tank the air on top of the water expands and thus gradually and at first somewhat rapidly loses its pressure.

Sizes and Capacities of Pressure Tanks. — Diagram Plate No. 1 exhibits in convenient form the relation between diameter, length and capacity of horizontal cylindrical water tanks. It gives the capacity from 100 to 10,000 gallons, for tanks varying in diameter from 1 foot 6 inches to 10 feet and in lengths from 1 foot to 40 feet.

In the upper left-hand corner is given a smaller diagram for tanks from 2 to 8 feet in length and from 12 to 48 inches diameter, and for capacities varying from 10 to 500 gallons.

Diagram Plate No. 2 will be found useful in determining the water capacities of partially filled horizontal pressure tanks. It gives the height of water in parts of the diameter D for fractional parts of Q, the area (or capacity) of the tank when filled being designated as Q.

Diagram Plate No. 3 is somewhat similar to the preceding one, its curve giving the contents in gallons of a cylindrical horizontal tank one foot long and one foot in diameter for various depths of filling. The capacities of tanks of any diameter and any length can be readily found by it.

While the conception of these three diagrams is not original with me, their construction and the calculations necessary for plotting the lines and curves were made by me specially for this chapter.

Requirements of Pressure Tanks. — The following **specifications for pressure tanks** have been issued by the Chicago Board of Underwriters, and the Table No. V will be found useful in practice.

"*Material.* To be of fire-box or flange steel, of even quality, having a tensile strength of not less than 55,000 nor more than 60,000.

Dimensions.

"*Heads.* Radius of dish to be equal to the diameter of tank.

"*Seams.* Longitudinal seams to be triple riveted and placed below the water line; girth seams to be single riveted, except where the diameter of tank is in excess of 34 inches, when double riveting should be employed; 'Hartford' specifications to govern; riveting to be done in a careful and thoroughly workmanlike manner; all seams to be thoroughly calked inside and out.

"*Manhole.* To be large enough to allow easy access to the inside of the tank and placed below the water line.

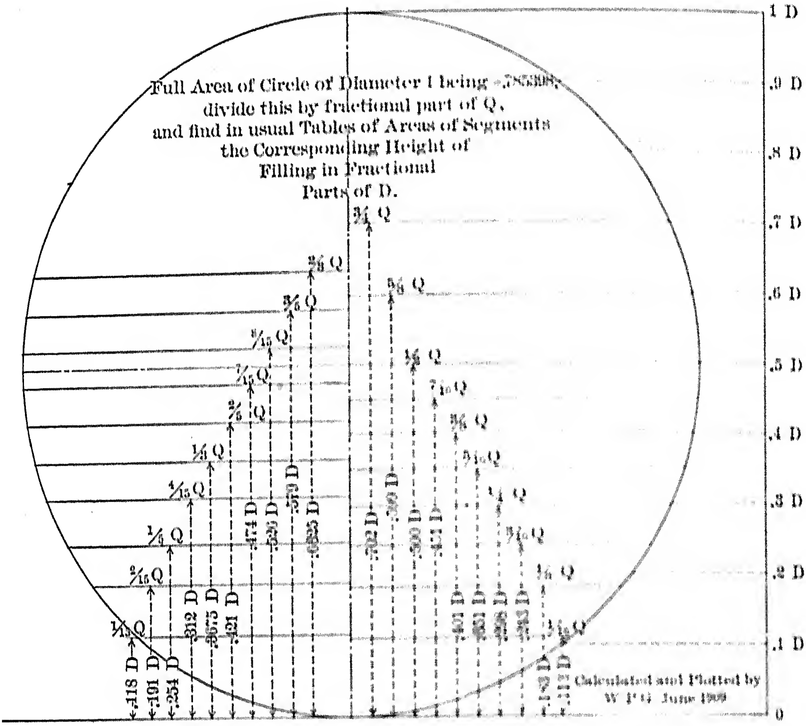


DIAGRAM 2. Capacities of Partially Filled Cylindrical Horizontal Pressure Tanks.

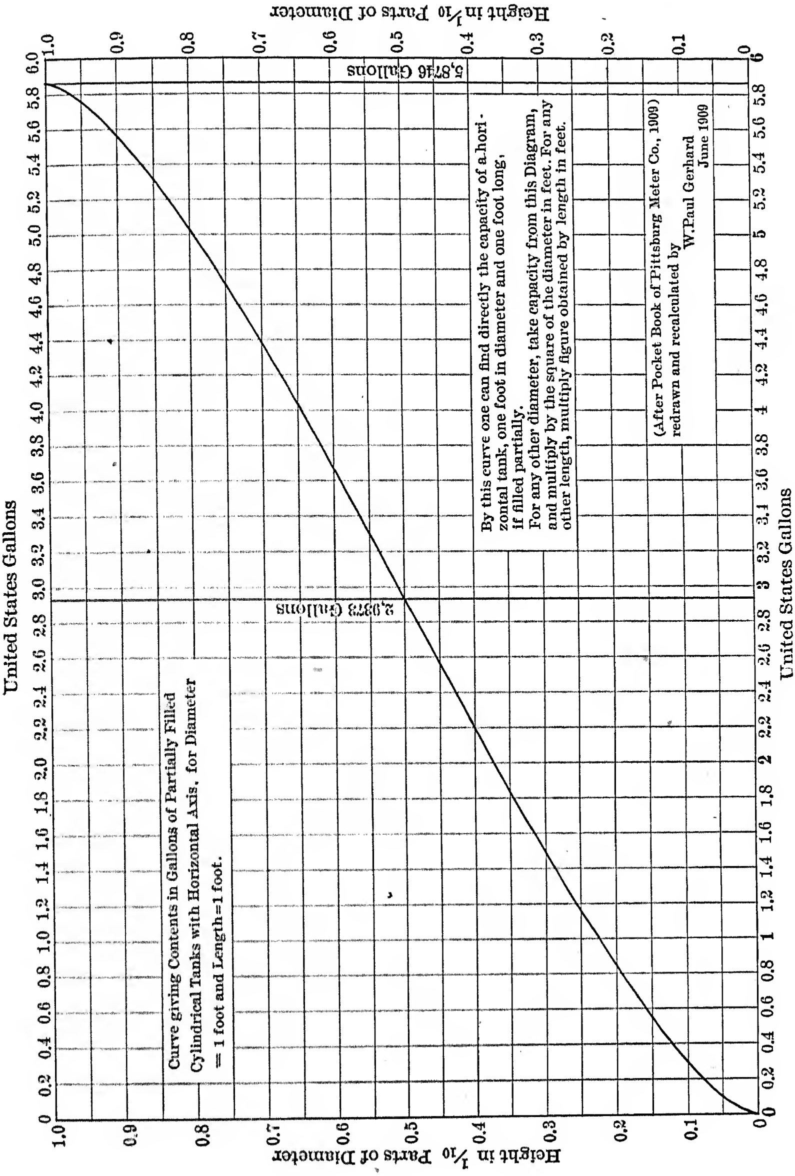


DIAGRAM 3. Giving Curve for Partially Filled Horizontal Tanks.

TABLE V.

	Inside Diameter of Tanks.						
	5′ 0″	5′ 6″	6′ 0″	6′ 6″	7′ 0″	7′ 6″	8′ 0″
Length of Shell, end to end........	30′ 0″	24′ 7¼″	20′ 6½″	17′ 3¾″	14′ 0″	12′ 8″	10′ 11″
Total Capacity in U.S. Gallons.....	4505	4502	4512	4500	4512	4516	4512
Water Capacity, ⅔ full....	3003	3001	3008	3006	3008	3010	3008
Height of Water Line above Bottom	38″	43¾″	45½″	49½″	55″	57″	61″
Thickness of Shell.......	⅜″	⅜″	7/16″	7/16″	½″	½″	9/16″
Thickness of Heads......	½″	½″	9/16″	9/16″	⅝″	¾″	13/16″
Dish of Heads	8″	8¾″	9½″	10¼″	11″	12″	13″
Usual Working Pressure.	75	to	85	lbs.	per	sq.	in.

"*Openings.* Discharge nozzle to be 6 inches, unless otherwise specified, and placed in bottom of tank, with 1½-inch side outlet threaded for filling and draining connections; inlet for air connection to be 1 inch and placed at proper point for upper gauge glass nipple, where suitable connections may be made for both purposes. Lower gauge glass opening to be ½ inch; tap ½ inch opening in top of tank for vent.

"*Gauge Glass.* To be placed on end of horizontal tank and side of upright tank so that water line will be at center of glass.

"*Test.* Tank to be tested and proved tight after installation, at a hydrostatic pressure of not less than 115 pounds."

Systems of water supply with single pressure tanks, filled partly with air and partly with water, the so-called **hydro-pneumatic systems,** are useful under certain conditions. For smaller country

houses and for farm buildings the pneumatic-tank system has undoubtedly great merits and affords advantages over the elevated storage tanks.

What seems to be a system similar to the one which I am about to describe is a pressure-tank system extensively used in France. It is the invention of an engineer, Mr. Carré, and consists of a series of water-pressure tanks in combination with a pumping plant and an air compressor. The latter is intended to compress the air at the top of the water tanks to a suitable pressure. The system received the indorsement of Mr. Bechman, one of the chief engineers of the city of Paris, in a report on the Paris Exposition of 1869, and has been in use many years in some large public buildings, not only for furnishing a domestic supply but principally to afford a good and efficient fire protection. Buildings in which these installations are used are the large National Library in Paris and the Hospital at Nantèrre.

Pressure-tank System with Separate Air Tank. — The "Acme" pressure-tank water-storage system is an American system, intended to furnish a supply and storage of water under pressure in tight receptacles or tanks, which are either buried in the ground below the depth to which the frost penetrates or placed in the cellar or in a chamber or vault located at or near the pumps.

It consists of one or several closed riveted steel water tanks, one or more similar air tanks, of water pumps, air compressors, the required air and water pipe connections, with gate valves between the several appliances and of pressure regulators. A certain normal air pressure is ordinarily carried in the water tanks, sufficient to cause the last gallon of water in the tank to flow out at the consumer's faucet under the normal pressure maintained in the air-pipe line by the pressure regulator. In the air tanks, however, a higher air pressure is maintained so that an increased pressure can be obtained for emergency cases, such as a conflagration, etc., by the opening of a by-pass valve, which instantly brings the full air pressure stored in the air tanks upon the water tanks. The water tanks may be made of any desired capacity, and their number is practically unlimited, while the capacity of the air tanks is proportioned to the former.

Advantages of the Acme System. — General advantages of the **Acme system** are that it does away with standpipes, elevated tanks

and with constant direct pumping. By providing separate air tanks for the storage of compressed air under a high pressure, the important advantage is gained that the water pressure in the mains can be increased at any time in case of emergency, and also that the pumping machinery may be shut down for repairs as soon as the water tanks are filled.

In this system it is feasible to run the pumps for a few hours only, and to store in the tanks the volume of water required during the remainder of the twenty-four hours. Economical advantages are thus obtained as regards the running expenses of the pumping plant, because the wages of a night engineer, or of the fireman, or of both, may be saved. Other advantages are the compactness of the plant, every part of the system being directly under the eye of the engineer and every controlling valve within his reach, and also its simplicity, the system being neither complicated nor liable to get out of order.

From a **structural point of view** an obvious advantage consists in the fact that the weight of the water stored in the tanks does not require to be placed at a high elevation as is the case with roof tanks for buildings or elevated tanks of waterworks. No expensive tower construction or heavy structural ironwork is necessary to carry the weight of the stored water. The pressure tanks may be placed either in a horizontal or in a vertical position and can be of any dimensions adapted to the available space. The system affords decided advantages **for fire protection,** for the pressure obtained is generally greater than that from a standpipe, and while the fire nozzles are in operation the pressure remains uniform up to the last, which is *not* the case with the standpipe or the elevated-tank system. For this reason it is somewhat of a surprise to me that the fire underwriters have not in the past called attention to the superiority of the system, as long as they have indorsed and permitted systems to be installed having only one combined air and water pressure tank.*

In the Acme system any desired volume of water is held in reserve normally under the pressure necessary for domestic consumption, which can be increased almost instantly to 100 pounds or more to meet the requirements of fire streams. In the case of village communities situated on level ground and having no buildings of extreme height the normal pressure carried in the water tanks, usually 40 or 50 pounds, suffices perfectly to extinguish a small conflagration.

* See Crosby and Fiske, "Handbook of Fire Protection for Improved Risks," second edition, 1901. New edition published 1909.

Of particular importance are the **sanitary advantages** which the system affords. Water is kept at a much lower and more uniform temperature in an underground or covered pressure tank than in elevated tanks, reservoirs or standpipes exposed to the sun. The freshness and purity of the water are maintained and no pollution of an originally pure water during its storage and on its way to the consumer can occur.

From a large personal experience I know the unsatisfactory, unsanitary and sometimes revolting condition in which the water in roof tanks is found to be, and also the difficulty of having the cleaning of the open roof tanks properly and frequently attended to. Water stored in open tanks is liable to contamination by ordinary street dust and floating organic matter, by gases emitted from chimneys and fireplaces, and by foul vapors from soil pipes opening on the roof in the immediate vicinity of the water tanks.

In closed storage tanks there is absolutely no chance for the contamination of an originally pure water. Neither is the water exposed to the deteriorating influence of light, heat and the atmosphere. This advantage is an important one in the case of ground-water supplies, which are so often unfavorably affected when stored in open reservoirs or tanks. Recent investigations have demonstrated the fact that certain algæ, which impart to water a fishy odor, or an oily taste, or both, are developed in water from underground sources through the action of air and light.

The fact that storage pressure tanks may be placed underground and out of sight will strongly appeal to owners or architects of buildings, for it is conceded that both the elevated tank and the open standpipe are usually decidedly unsightly and objectionable. This is true both of roof tanks on city buildings and of elevated tanks required for country buildings; it applies in particular to the open and exposed standpipe constructed of boiler iron or steel plates, erected in all parts of the country as an inexpensive form of water storage for communities.

From a **military point of view** a special advantage is that the entire water plant of a fortified town or of a military post may be located underground and thus be concealed from view, except possibly the smokestack for the steam boilers or the exhaust for the gasoline engines which run the pumps. Even these are done away with where pumping by electricity is feasible. Thus arranged it would not be an easy matter for the enemy, in case of war, to discover and injure the water plant.

For villages and small towns the principal advantages are that the cost of a reservoir or the cost of a standpipe or elevated tank for water storage may be saved. The pressure tank in combination with an air tank has the advantage over standpipes that there is no danger from ice formation in winter or collapse of the standpipe due to sudden violent wind pressures.

The system is also particularly adapted for the water supply of a group of buildings of an institution and for the grounds surrounding them. Where the various buildings are scattered a compact central plant placed entirely underground, erected at any convenient point, will uniformly supply the buildings under the desired pressure of water. The system permits of the use of any kind of motor and pumping apparatus, such as steam pumps, gas, gasoline or oil engines, electric motors, and even hand pumps for very small plants.

All the sanitary and other advantages mentioned heretofore apply where the system is used for single city buildings of great height, such as office buildings, apartment houses and hotels, etc. It is a decidedly better system than the one of pumping directly into the service lines and risers, or the system which uses in connection with direct pumping a small and utterly inadequate roof tank. (See Chapter VI.)

The fire protection obtained from the system for inside standpipe lines cannot be obtained from the roof tanks. For isolated country mansions the system is, of course, particularly adapted, and where both water supply and electric lighting are required for country houses it is possible to install a plant answering for both purposes.

Pumping Water. — As important as the means for storing the water are the means for lifting it so as to make it available for use in buildings. Many different forms of **pumps** are used for this purpose. The simpler kinds of pumps are the suction, hand lift and force pumps, the chain pumps, pumps operated by animal power, and windmill pumps. Forms of pumps operated by the energy of the fall of water are the hydraulic ram, the various types of water wheel and the hydraulic turbines. More or less complicated but also more efficient forms of pumps are the hot-air, gas and gasoline pumps, the reciprocating piston and plunger and the centrifugal steam pumps, to which in recent years have been added pumps operated by the electric current. (See Chapter VI.)

Conduits. — Water-supply **conduits** may be either **open** or **closed** and covered; they may be gravity or pressure conduits. The long masonry conduits which carry the water across valleys are known as **aqueducts.**

Valves. — In water-supply and plumbing work various kinds of **valves** are in use. These are named (*a*) from the device with which or the place where they are connected, such as angle valves, bucket valves, hydrant valves, pipe valves, pump valves; (*b*) from their shape, construction or mechanism, such as conical valves, cup

valves, annular valves, screw-down valves, back-pressure valves, compression valves, full-way or gate valves. (See Definitions in Appendix.)

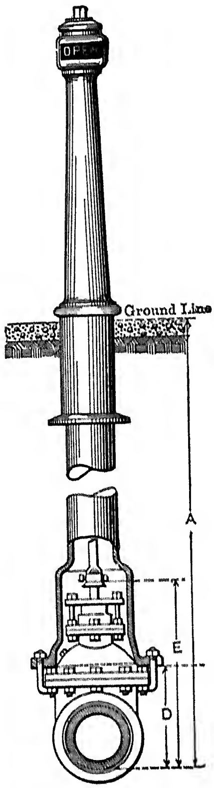


FIG. 32. Valve Indicator Post.

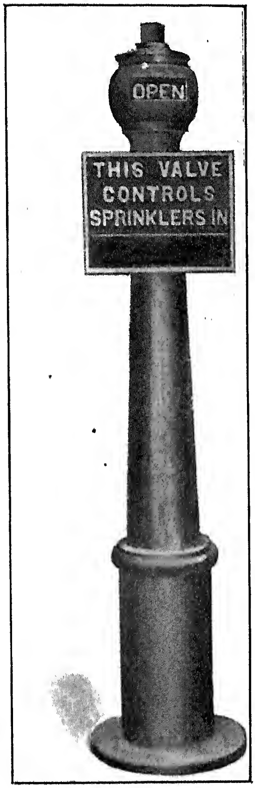
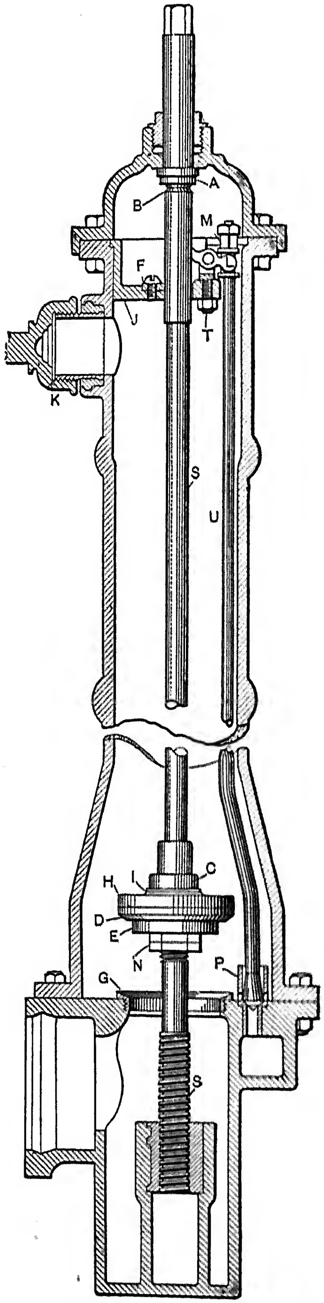


FIG. 33. Valve Indicator Post.

Indicator posts, Figs. 32 and 33, are used in connection with a gate valve located in a line of pipe underground or under a floor, when it is desirable to know whether or not it is open. The words "Open" and "Shut" are on plates that indicate the position of the gates in the valve from either side of the post.

For fire-protection purposes these indicator posts are important, for a conflagration might occur with disastrous results owing to the fact that valves supposed to be open were closed. Indicators should therefore always be used in connection with the fire service of factories and of public institutions.

Hydrants. — Every waterworks system requires for fire-protection purposes a number of **fire hydrants** located along the distribution-pipe system. Sometimes these hydrants are used also for the filling of the street-sprinkling carts, while in other cases special hydrants are used for this purpose. There are two principal types, namely, the **post hydrant,** shown in section in Fig. 34, and the **flush hydrant** (Fig. 35). The former is the common form in the United States; the latter is more frequently used in Europe. Hydrants are always so constructed that their pipes are left empty when the hydrant valve is closed and the hydrant not in use.



Valve open, Drip closed

FIG. 34. Section of Post Hydrant.

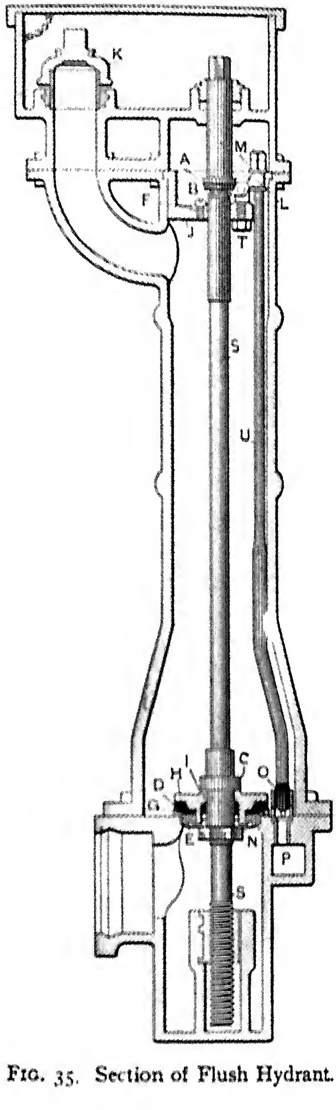


FIG. 35. Section of Flush Hydrant.

Water Supply of Buildings.

For the maintenance of a well-arranged system of plumbing and house drainage in buildings a perfect system of water supply and distribution is required. The water supply and the sewerage of habitations are correlated, each requiring the other in order that their objects may be well and satisfactorily fulfilled.

The water supply of dwelling-houses will be described in detail in Chapter V, and that of the larger modern office and other buildings in Chapter VI.* The following paragraphs are intended to give a condensed summary of the subject.

The **water supply of buildings** varies according to the source of supply and the available pressure. In cities, it is derived from the network of street mains which form the water-distribution system; for country houses it is often necessary to install an independent supply derived from dug, driven or bored wells, rain-water cisterns, springs, brooks, creeks and streams, or from lakes.

Supply Systems. — The plumbing appliances in buildings are supplied either from **direct street pressure,** or **from house tanks,** or by a combination of both systems. Where the pressure in the street mains is high, house tanks are unnecessary; but country houses usually, and city houses sometimes, require tanks in order to store the water pumped. A combination of both methods becomes necessary in districts of cities where the pressure is insufficient to reach the upper floors of buildings at all hours of the day. (See Chapter V.) In such cases tanks are provided which are filled from the pressure, where this is higher during the night hours; where doubt exists as to this being always the case, the tanks are filled by means of house pumps.

In country houses, however, the water must always be lifted to the tanks by pumps. Pumping is likewise required when pressure tanks are used. Drinking-water should, where possible, be supplied from direct street pressure.

In some instances the pressure in the street mains is too heavy, and in this case house tanks are useful in preventing the quick wearing out of the plumbing system.

* The special features involved in the water supply of country houses are to be found in the author's book entitled "The Sanitation, Water Supply, and Sewage Disposal of Country Houses," 1909.

House Tanks. — House storage tanks are constructed either of wood or of steel. If of wood they are either built of staves in round form like coopers' tanks, or they are made of narrow boards and their inside lined with tinned copper. Lead-lined and galvanized iron tanks are unsafe, owing to the danger from water standing long in contact with these metals. Painted wrought-iron tanks are also much used. All tanks except those placed on the roofs require tank safes, iron tanks particularly so because they sweat in summer owing to condensation. Tanks should always be provided with covers to exclude dust; these are indispensable when the tanks are located on the roof.

Tank overflows should discharge on to the roof or into a sink in the lower part of the house; they should never connect with a soil or waste pipe. Emptying pipes should be provided for cleaning out the tanks, and these as well as the safe wastes may discharge on the roof; a connection with a soil or waste pipe is not permissible. Tanks should be supported on heavy steel beams.

Water Mains and Service Pipes. — The **street mains** are of cast iron and the **service pipes** of galvanized wrought iron or of heavy lead pipe. Brass taps or **corporation stopcocks,** usually $\frac{1}{2}$ and $\frac{5}{8}$ inch in diameter, connect the service pipe with the street main. The larger residential buildings are supplied from one or several $\frac{3}{4}$-inch, and sometimes by 1-inch services through water meters. Public buildings require supply pipes varying from 2 to 4 inches; theater buildings and manufacturing establishments require 6-inch mains for fire protection.

Diagram Plate 4, for the discharge of large water mains, has been enlarged and recomputed by the author from a similar one in the fourth edition of the "Handbuch der Ingenieur-Wissenschaften," the metric measures and values being changed by him to English values.

This diagram is based upon one constructed by Professor Baumeister in 1884. The horizontal line gives the volume of water in cubic feet per second; the vertical lines indicate velocity of water in feet per second. The inclined lines represent the diameter of pipe in inches, and the curved lines indicate the ratio of fall to length. Each curve, as will be seen, has two values for J, the smaller one being for a coefficient of roughness $b = 0.27$, the larger one for coefficient $= 0.45$.

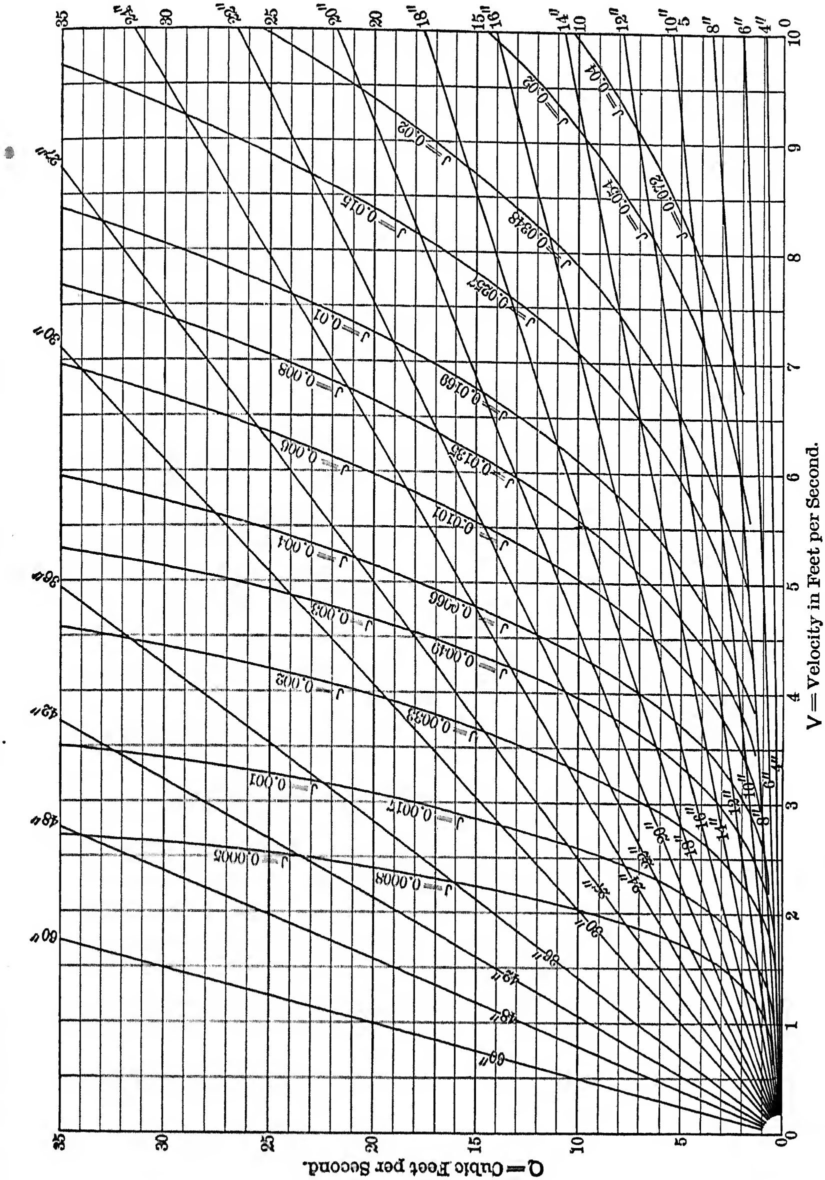


DIAGRAM 4. For the Discharge of Water Pipes Four Inches in Size and Up.

The diagram is worked out from the Kutter formula,

$$\text{Velocity} = \frac{a\sqrt{R}}{b+\sqrt{R}} \times \sqrt{R \times J},$$

in which a = 100 and b represents one of 12 coefficients of roughness varying from 0.12 to 2.44.

$$R \text{ represents } \frac{\text{sectional area filled}}{\text{wet perimeter}}.$$

Example. — To discharge 15 cubic feet per second, with J = 0.002 (coefficient of roughness = 0.27), a pipe 27 inches in diameter is required. The velocity of flow would be 3.6 feet per second.

Supply Pipes. — The water pipes inside of buildings are of different materials, viz., either of lead, of galvanized wrought iron or of tinned brass.

Sizes of Supply Pipes. — Table No. VI gives the usual sizes of pipes used in dwellings for the supply of plumbing fixtures.

TABLE VI.

Main Supply or Service Pipe.....	1¼ 2″
Supply to House Tank..............	1¼-1½″
Pump Risers..............	1½-2″
Supply to Kitchen Boiler..............	1-1¼″
" " Laundry Boiler..............	¾-1″
Supply Risers to Bath Rooms [hot and cold]......	1-1½″
Branch Supply to a Water-closet Cistern..........	½″
" " " Bath Tub..............	¾″
" " " Wash Basin..............	½″
" " " Pantry Sink..............	½″
" " " Kitchen, Scullery or Slop Sink...	¾″
" " " Urinal Cistern..............	½″
" " " Needle and Shower Bath......	1-1½″
" " " Sitz or Foot Bath or Bidet......	½″
" " " Set of Laundry Tubs..........	1″
Water-closet Flush Pipes..............	1¼-1½″
Urinal Flush Pipes..............	¾-1″

Arrangement of Supply Pipes. — The supply pipes should always be run so that they may be completely emptied when the water is shut off; rising lines should be kept exposed and not be placed in outside walls or in plastered partitions; wherever necessary, supply pipes should be protected against freezing. Every branch from a riser or distributing line should be provided with shut-off valves and air chambers.

Freezing of Pipes. — Service pipes, tanks, flushing cisterns and water-supplied fixtures should not be placed where they may be exposed to frost.

Faucets and Shut-offs. — Special devices are used for governing the flow of water through the house pipes, such as **ball cocks,** for

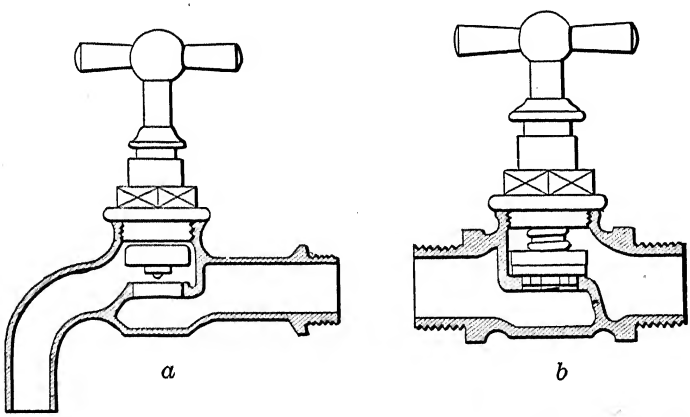


FIG. 36. Form of Faucet and Stopcock Used in Experiments to Determine Discharge Given in Table VII.

cisterns and tank supplies; **stopcocks** in the line of pipes regulating the flow of water through it; and **faucets** or **bibcocks,** placed at the ends of branches for the supply to fixtures. These are constructed either as ground key work with all-metal tapering plugs, or as compression work with compressible washers. Round-way cocks give a better flow of water than the ordinary kind. The compression cocks are either hand-closing or else self-closing. (See also Chapter V.)

Delivering Capacities of Faucets. — The following table, published by a German firm of manufacturers, gives the discharge of faucets and shut-off cocks of the compression or screw-down type, constructed as shown in Fig. 36, *a* and *b*. In this special type of

TABLE VII.

Giving Discharge of Faucets, under Different Pressures, in U. S. Galls. per Minute.

Head or Pressure		¼″	⅜″	½″	⅝″	¾″	1″	1¼″	1½″
in lbs.	in ft.								
7.	16.4	1.32	2.86	4.84	7.05	11.01	18.94	28.63	39.64
14.	32.8	1.98	4.84	7.93	11.89	17.62	31.71	48.44	66.06
28.	65.6	2.64	7.05	11.01	16.74	26.42	44.04	66.06	92.48
42.5	98.4	3.30	8.37	13.65	20.70	32.59	55.05	83.68	114.50
57.	131.2	3.74	9.69	15.85	23.78	37.43	62.98	94.69	132.12
71.	164.0	4.18	11.01	17.62	26.42	41.84	70.46	105.70	149.74
85.	196.9	4.62	11.67	18.94	29.07	45.36	76.19	114.50	160.75
99.	229.7	4.84	12.33	20.70	31.27	49.32	82.80	123.31	176.16
113.7	262.5	5.06	13.21	22.02	33.47	52.85	88.08	132.12	187.17
127.9	295.3	5.28	14.09	23.34	35.23	55.49	93.36	140.93	198.18
142.	328.1	5.51	14.97	24.66	37.43	59.01	99.09	149.74	206.99

fitting the waterway when the bib is opened, as in *a*, is larger than in ordinary compression bibs. The hydrostatic head was measured directly at the bib. The values for the discharges given in the table are for bibs placed at the end of a line of supply pipe, as at *a*. For shut-off bibs in a line of pipe, as at *b*, the discharge would be somewhat smaller than given, the percentage of deduction depending upon the friction in the pipe line, *i.e.*, upon its length and diameter.

Delivery of Water through Service Pipes. — Table VIII gives the amount of water delivered by clean new supply pipes of different diameters under various heads of pressure and lengths of lines. A diagram of the discharge of service pipes, taken from Coffin's book on "Hydraulic Calculations," is given in Plate 5. Other diagrams of the discharge of service pipes may be found in Chapters VI and VIII.

Pressure Regulators. — Pressure regulators are applied where the water pressure in the district and in the service pipes is very heavy. An excessive pressure tends to strain the house supply pipes, increases the trouble due to water hammer, and is apt to cause a quick wearing out of the supply pipes and fittings.

There are numerous patterns and types of **pressure regulators,** and the majority make use of brass springs in connection with balanced valves, and are provided with an adjustment device to obtain any pressure reduction desired (Figs. 37 and 38).

Pressure regulators should not be used where not absolutely necessary, as they often give trouble and get out of order, chiefly so in the case of waters containing sand, grit or other foreign substances.

Water Meters. — These are devices used to measure and control the consumption and to check the wasteful use of water, particularly in manufacturing establishments and in large city buildings generally.

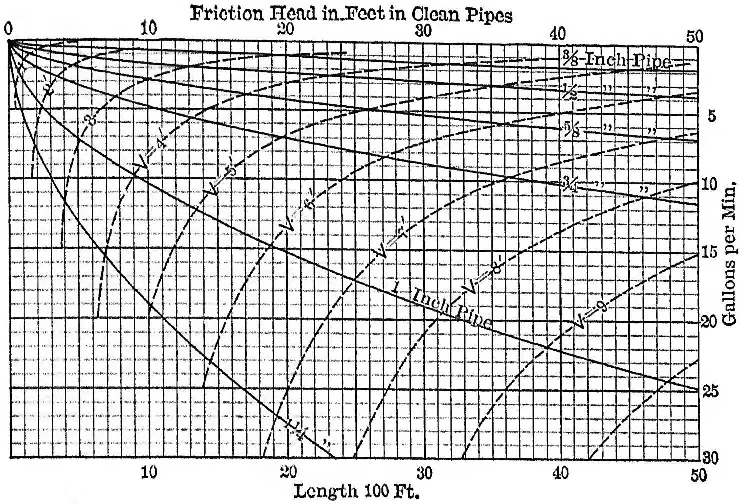
Filtration. — The water supply for cities or communities is filtered on a large scale by means of **artificial filter beds,** composed of layers of gravel and sand; this method is called the sand-filtration system. The filter basins are either open or covered. The reservoir for the storage of the filtered water should always be covered.

Domestic or household filters are intended for use in individual

TABLE VIII.

Discharge of Water Service Pipes after Hubbard's Diagram, based on Weston's Formula.

Diameter of Pipe in Inches.	U.S. Gallons delivered per Minute.	Loss of Head per 100 ft.
½″	1	3.5
	2	12
	3	23
	4	39
⅝″	2	4
	3	8
	4	14
	5	20.5
	6	28
	7	38
¾″	3	3.5
	4	6
	5	9
	6	12
	7	16
	8	20
	9	25
	10	30
	12	42
1″	5	2.4
	6	3.3
	7	4.2
	8	5.5
	9	6.8
1″	10	8
	12	11
	14	14.5
	16	18
	18	22
	20	28
	30	58
1½″	10	1.2
	12	1.7
	14	2.2
	16	2.8
	18	3.4
	20	4
	30	8.5
	40	14
	50	22
2″	20	1.1
	30	2.2
	40	3.8
	50	5.6
	60	7.8
	100	19.5
	150	40
	200	65



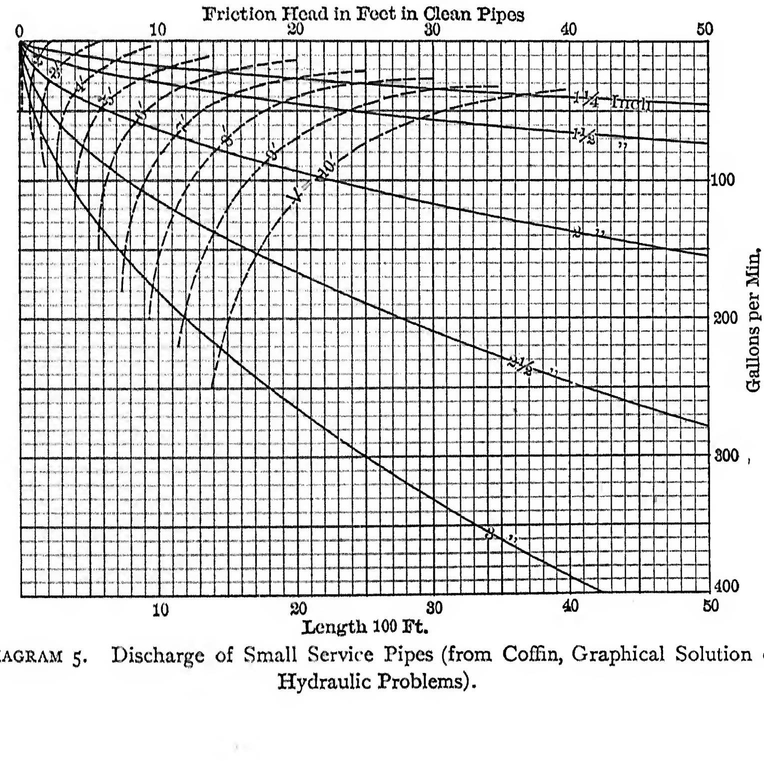


DIAGRAM 5. Discharge of Small Service Pipes (from Coffin, Graphical Solution of Hydraulic Problems).

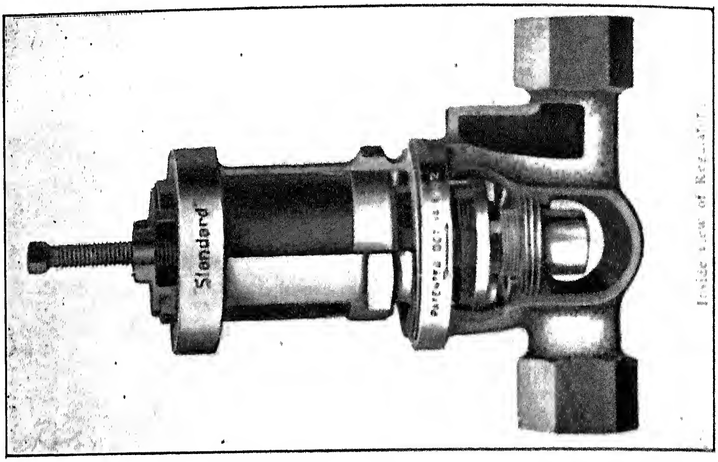


Fig. 38. Pressure Regulator.

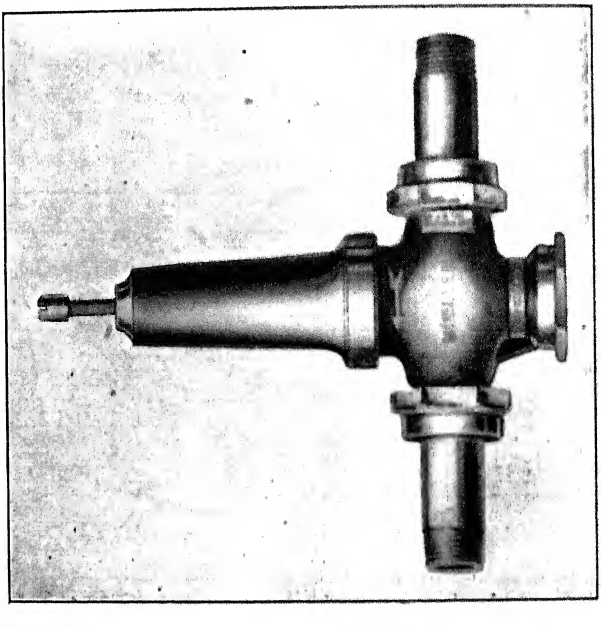


Fig. 37. Pressure Regulator.

buildings and are of two types. The pressure filters, which represent the first type, are placed in the line of the main service pipe of buildings, and they clarify the entire water supplied to the buildings; they are usually designated as **mechanical filters.** The other type consists of filters of comparatively smaller capacity attached to the faucets or nozzles. They are termed **drinking-water filters,** and some of the types in common use are the Pasteur-Chamberland and the Berkefeld filters. They render the water practically germ-proof, but require cleaning at frequent intervals and also occasional sterilizing. The filtering material is either porcelain or infusorial earth compressed artificially into a kind of stone, or else some natural stones of fine grain are used. In the larger mechanical filters the material used is either sand, gravel, charcoal, iron oxide, quartz, or other material.

Work of the Plumber.

There was a time when plumbers used principally **lead** as material for their work, and the name of the craft was derived from it. Soil pipes were made of sheet lead rolled into cylindrical forms and soldered at the edges. Cisterns, tanks and sinks were lined with lead, and the roofs of buildings were covered with it. The old-fashioned hand-made traps, the rain-water heads, gutters, leaders and flashing consisted of this metal. Later on, cast-lead pipes came into use, and they in turn were superseded by drawn-lead pipes, bends and traps. The tedious work of bending pipes by hand is now done away with. Traps are made of drawn lead and are superior because they have no sand holes such as the cast-lead traps had, and because they have no soldered seams at which the old-fashioned hand-made traps frequently opened up.

Pipes and Pipe Joints. — A large part of the plumber's work consists in running pipe lines and in the jointing of these pipes.

The **material for pipes** differs according to the service which they have to perform.

For soil and waste pipes the plumbers use heavy cast-iron or asphalted or galvanized wrought iron; heavy lead pipe is used for the short branches.

For vent pipes they use heavy cast-iron, galvanized or lead-lined wrought-iron, heavy lead and brass pipe.

For drain pipes they use earthen, cement and extra heavy cast-iron pipe.

For supply pipes, heavy drawn-lead, plain black, galvanized, enameled, lead-lined, tin-lined and glass-lined wrought-iron pipes, or else tin-lined lead pipe or tinned brass and copper pipe.

For suction pipes from cisterns and wells, tin-lined lead and block-tin pipe.

For illuminating gas, natural gas, acetylene gas, black or plain wrought-iron pipe, galvanized-iron pipe, and, for exposed piping, brass.

For steam, plain black wrought-iron pipe.

For gas and water street mains, heavy asphalted cast-iron hub pipes, cast-iron Universal pipes with lugs, asphalted or cement-lined wrought-iron pipes, and wooden-log pipes.

Pipe joints differ according to the material of the pipes. Glazed earthen pipes are jointed with cement; cast-iron pipes with oakum and molten lead; lead pipes by solder-wiped joints; brass and wrought-iron pipes by screw joints; copper pipes are jointed by soldering and brazing; lead and iron pipes are connected by means of brass ferrules or nipples, and lead and brass pipes are joined by solder-wiped joints.

With progress in manufacturing, better and stronger materials than lead pipes became available for the plumber's work. The cast and wrought iron pipes for water, sewage and gas lines, and the copper and brass pipes, fittings and traps for interior plumbing work, have to a large extent replaced the former lead work and given to plumbing work an entirely different character. In the modern American plumbing comparatively little lead work is used, whereas in England and France the trade still uses to a large extent lead soil, water and gas pipes.

The journeyman of to-day should understand not only the wiping of soldered joints, but he must also be able to make screw joints in wrought-iron and brass piping, lead-calked joints in cast-iron pipe, as well as flange joints and other special joints in block and tin-lined pipes.

Other Work of the Plumber. — Plumbers' work comprises the running of soil and waste pipes and of house sewers; the installation of sewage-lifting apparatus or of sewage ejectors; the tapping of street mains and inserting of corporation stops, the bringing of water services into buildings, and the proper running and distribution of the supplies for the plumbing appliances, tanks and hot-water boilers; the fitting up of water meters and the setting and connecting of water-lifting apparatus, such as hand lift and force pumps, hot-air pumping engines, steam and gas pumps, water motors, electric and fire pumps.

Quite often plumbers fit up cooking ranges for coal or for gaseous fuel; they also make the connections of the water backs or pipe coils in the range with the kitchen boiler, hence they should thoroughly understand how to obtain a perfect hot water supply distribution and hot-water circulation.

Installing Fire-protection Apparatus. — Plumbers' work embraces the installation of fire-protection apparatus in buildings, such as special fire pumps, standpipes, fire valves and fire hose.

In theaters, institutions, and in manufacturing establishments, as well as in high office buildings, the plumber erects the standpipes for fire protection; sometimes he installs the entire fire-extinguishing apparatus. In some cases fire standpipes are run on the outside of buildings, with branches provided for all of the floors, and with one or several fire department connections at the bottom of the line, to which the fire engines are connected. Such standpipes are called "dry" because they are ordinarily kept empty. More usually, the standpipes are placed on the inside of buildings, with branches and fire valves on every floor, and equipped with standard fire hose and fire nozzles attached to the valves, and the line is always kept full of water in occupied buildings heated in winter time, in order to be instantly available in case of fire.

The recent fire department rules of New York City require every building exceeding 85 feet in height to be provided with an interior standpipe, which must be from four to six inches inside diameter, according to the height, with $2\frac{1}{2}$-inch branch outlets on each floor, and which also must be extended out to the street in front of the building and there provided with a Siamese fire department connection.

Setting Plumbing Fixtures. — The plumber should be thoroughly conversant with the setting up of the numerous kinds and types of plumbing fixtures and understand how to connect them with the soil and waste pipes in such a way as to secure a quick and safe removal of the waste water or house sewage, and at the same time a perfect exclusion of the sewer air. He should in particular know how to avoid dangerous by-passes in the plumbing system. A number of such by-passes or faulty connections due either to ignorance or carelessness have been shown in the illustrations, Figs. 26–29.

Gas Piping Work. — At the present time the plumber also fits up buildings with gas pipes, for lighting, cooking, heating and power purposes. Formerly such work was done exclusively by a separate trade of gas fitters. In country houses he also sets up and connects the machines for the generation of lighting gas.

Plumbing Work of Country Houses. — In the case of country residences, the plumber often provides pressure or gravity conduits for bringing the water from a spring, a reservoir or a mountain lake to the buildings; he also sets up hydraulic rams, erects windmill pumps with tower tanks or with pneumatic pressure tanks. He digs or drills wells for water supply, and builds underground reservoirs or cisterns for the storage of rain water. In connection with cisterns he puts up the pipes which are to convey the water falling upon the roofs. His work also includes the fitting up of rain-water cut-offs on the leader pipes, of filtering chambers for the rain water, and the pipe connections between pumps and cisterns or wells.

Plumbing of Bath Houses. — Under the direction of architects or of sanitary engineers plumbers fit up public bath houses, and put in the piping installations of swimming-baths, of Turkish and Russian baths and of special hydropathic establishments.

Special Work. — Special plumbers' work is the fitting up on board of ships and yachts of ship closets, lavatories, baths and sinks. In large hotel kitchens, and in kitchens and laundries of public institutions, plumbers make the numerous connections required for steam cooking kettles, for laundry machinery, etc. (See Gerhard's Kitchens and Laundries, Chicago, 1910.) Plumbers also fit up water sterilizers and mechanical or pressure filters.

Future Progress in Plumbing. — At the time when water was first introduced into habitations, plumbing work was a very simple affair compared with the very intricate and elaborate plumbing system of the large modern buildings. But while it is true that much progress has been made in the art of fitting up buildings with plumbing conveniences of all kinds, the manual work of the plumber has not advanced so much. Future improvements should be directed towards a more accurate and **mechanical workmanship.** By this I mean that it should be possible to lay out the plumbing work and fit it in the shop in much the same way as the machinists turn out their work in the erecting shop. This would enable a more rapid and more accurate putting together of the several parts to be assembled at the building.

CHAPTER II.

SANITARY FIXTURES AND APPLIANCES.

MODERN CONVENIENCES: THEIR DANGER AND HOW TO AVOID IT.

MODERN town and country houses are rarely considered finished and completely furnished unless they contain a fair number of **household conveniences.** Among the latter, the domestic sanitary fixtures and appliances constitute, doubtless, those of the greatest importance, for unless carefully and judiciously selected and fitted up in accordance with the best rules of modern sanitary drainage, they may, instead of being a comfort and a labor-saving convenience, turn out to be health-endangering features in a dwelling.

Indeed, the innumerable instances of **bad plumbing** and **defective drainage** of the past years have caused many prudent householders to look with suspicion upon plumbing generally. The sensational writing of some sanitarians has also done much to create a feeling of distrust and fear against sewers, house drains and the fittings and fixtures connected with them.

Some medical practitioners, too, have contributed their share towards increasing this feeling of suspicion. Years ago, Dr. Frank Hastings Hamilton, in a well-known and much-discussed essay entitled "The Struggle for Life against Civilization and Æstheticism," reached the following conclusions:

> "In order to render pure and innocuous the atmosphere of our houses, whether the sources of its impurity are to be found in our present system of lighting, heating or drainage, it will be necessary, first of all, that civilization should make some concessions. . . . If we limit ourselves to the consideration of the unwholesome atmosphere of our houses — although this does not by any means constitute the only possible or probable source of sickness and physical decay incident to civilization — the concessions demanded, as a condition of the successful application of our present knowledge of the laws of hygiene, are:

> "That all plumbing having any direct or indirect communication with the sewers shall be excluded from those portions of our houses which we habitually occupy. In other words, that it shall be placed in a separate building or annex."

The concessions suggested by Dr. Hamilton, which refer to heating and lighting our homes, are omitted here purposely.

Let us consider whether the learned writer of these paragraphs was right in what he said concerning plumbing work, and whether his suggestion of placing all plumbing fixtures in a separate annex to a house is the only remedy for the dangers incident to bad house drainage.

Sanitary Arrangements and Appliances.

The object of all **domestic sanitary appliances** is to facilitate good housekeeping by reducing the trouble and labor and by furthering neatness and tidiness of servants, to aid in establishing perfect cleanliness in the household, and to increase the convenience and comfort of a house. Indeed, the influence of good sanitary appliances upon the health of body and mind of individuals can hardly be questioned, provided, of course, the fixtures are properly arranged and properly taken care of. To do entirely without "modern improvements" would be almost as impossible as it would be to do without railroads, steamboats, telegraph wires and telephones.

There is, nevertheless, a certain amount of truth in the statements quoted, if we apply them to the actual condition of plumbing, heating and lighting arrangements as found in the majority of existing buildings. After many years' experience in the sanitary inspection of buildings both in cities and in the country, I am safe in positively asserting that there are but very few older houses which are habitable from a sanitary point of view.

As a rule, plumbing work done twenty-five or more years ago is radically defective, and such is also undoubtedly true of the heating arrangements, whether by stove, furnace, steam or hot-water apparatus, whether by direct or indirect radiation, and it applies equally to the fixtures and pipes serving to light our dwellings with illuminating gas. All these appliances combined continually tend to contaminate the atmosphere in our houses, and to this air, ren-

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dered measurably impure, much illness and continued low condition of health may, undoubtedly, be attributed.

An enumeration and description of the most usual defects would alone fill a volume. Books, large and small, popular and scientific, are readily accessible in which defective work and its injurious influences upon health are described. I shall not give a long and startling account of the common features of faulty work, but will merely state that, in my judgment, such defects are avoidable and that it is perfectly feasible to enjoy the advantages of "modern conveniences" without following the extreme views maintained by some theoretical sanitarians. It is certainly undesirable, and it is not necessary, to banish all plumbing fixtures to an annex separated from the main building. It is likewise possible to light our rooms with illuminating gas and to heat and ventilate our dwellings with steam or hot-water apparatus, or by a warm-air furnace, in a safe, agreeable and healthful manner, retaining, however, in the principal rooms, for the sake of ventilation, the welcome fireplace. Doubtless it becomes necessary to make a few concessions to secure safety, but the sacrifices required are not such, I believe, as would meet with much opposition.

General Advice on Sanitary Matters.—First, I advise in awarding contracts for work on buildings, to keep entirely *separate from the builder's contract* the plumbing and drainage work, the heating and also the lighting. Separate estimates should be received for these important branches from reputable firms, and the contract awarded to a responsible man in each line of work, or else the work should be done by the day on a percentage basis. Subsequent repairs become necessary very soon wherever work of this character is done in a hasty and superficial manner, without proper supervision, and by the man who puts in the lowest bid. Annoying repairs are almost entirely avoided where the above advice is followed.

Second, I recommend to *employ* in the work none but *first-class* tradesmen and *mechanics* with large experience, who have the reputation of being thoroughly competent and honest.

Third, I advise using only *first-class material*, fittings and appliances. By "first class" I do not mean appliances of more than usual elegance, enriched by expensive decorations and fitted with costly cabinet work. On the contrary, I refer to plain and simple

appliances, in the manufacture of which, however, the best available material and best workmanship have been combined. Such apparatus, it is true, will cost more at first than the usual sum set aside for such work, but it will pay better in the end to select only fixtures and fittings of the best manufacture.

Fourth, no more sanitary fixtures than are actually needed should be put in a house, and all plumbing which will not be in daily and constant use should be avoided.

Fifth, I recommend that *no plumbing* appliance of any kind be placed *in any bedroom* or unventilated closet adjoining it. In other words, all plumbing should be confined to the bath rooms, toilet rooms, the kitchen, scullery, pantry and laundry. This will necessitate doing without the "set" bowls in bedrooms so often scattered all over a house. I advise doing this, because it is better not to run even a slight risk in adopting the so-called "modern conveniences." While I shall hope to be able to demonstrate that plumbing can be so arranged as to be perfectly harmless in a well-ventilated bath room, the risk of exposure to sewer air from an opening into a sewer from a bedroom, even when such opening is trapped, cannot and should not be disregarded. To quote from Clarence Cook's "The House Beautiful":

> "There is one customary enemy to be got rid of in the bedroom, and that is the fixed washstand. This machine is useful enough in public places, in hotels and restaurants, but ought to be banished, both for sanitary and æsthetic reasons, from our domestic life. Leaving out of view the expense of plumbing arrangements, — their liability to get out of order, the frequency with which they get stopped up, and freezing in the winter, and all the evils water and drain pipes are heir to, — I believe it is now admitted that the drain pipes are the source of a great deal of disease of our cities and even our country towns. Convinced of this, and seeing no certain way to prevent the evil so long as drain pipes are allowed in bedrooms, many people nowadays are giving up fixed washstands altogether, and substituting the old arrangement of a movable piece of furniture with movable apparatus, — the water brought in pitchers, and the slops carried bodily away in their native slop-jars."

Finally, I warn against the widely spread belief that plumbing work — and heating apparatus as well — once finished, may be left to the management of ignorant domestics, and that they require no looking after. This view is indeed an erroneous one, and I

would advise doing away with plumbing fixtures altogether rather than to run such risks. This will, I hope, become more apparent in the subsequent discussion and detailed description of the appliances which I consider suitable for use.

It must be conceded that it is desirable to have the utmost **simplicity of arrangement,** and that all useless complication of such work is to be avoided, but, on the other hand, convenience of use should not be lost sight of.

Every room and closet of a house, containing plumbing apparatus, should be amply provided with air and light. How to arrange plumbing fixtures in such a manner as to secure immunity from sewer air, and how the much-needed flushing of traps and waste pipes and the equally desirable ventilation of the whole waste-pipe system can be effected, has been pointed out in the preceding chapter. How best to avoid all manner of complicated movable machinery, in the shape of valves, cranks, levers, wires, rods, etc., and how the fixtures may be so arranged as to secure cleanliness and freedom from any dirt accumulation, will be discussed later on.

Plumbing Fixtures in General.—Before I describe more in detail the various appliances which in my judgment are best adapted to the needs of residences, I desire to say a few words in general about **plumbing fixtures.**

The selection of suitable apparatus is a matter of the greatest moment, inasmuch as household cleanliness must depend to a large extent upon its character and arrangement. And here I find myself quite at variance with some sanitary advisers who emphasize only the requirement of a proper system of drains, waste pipes and traps, claiming that "if the drainage pipes of a house are well ventilated, and the branch pipes from fixtures well trapped, it makes little, if any, difference what kind of apparatus is connected to them."

While I admit that a number of undesirable or bad appliances attached to a well-devised pipe system cannot do the same amount of harm as the very best fixtures if set upon badly arranged and ill-ventilated or untrapped pipes, yet it appears to me very important and decidedly better in the end to use care and judgment in order to obtain a system of drainage which will be *perfect in all respects,* in other words, with faultless traps and faultless pipes, but also

with faultless fixtures. As the object of a good system of town sewerage may be entirely defeated by a defective system of house drainage, just so may the best system of soil and drain pipes in a building fail to give satisfaction on account of improper fixtures or traps.

Plumbing fixtures, to begin with, **should be concentrated** in a dwelling as much as possible, and not scattered about in all directions. One should avoid a multiplication of soil-pipe stacks, or the equally objectionable alternative of long lateral waste pipes which must of necessity be carried with insufficient fall, and which often require a deep notching of the floor joists. Each fixture should, if possible, have an entirely separate and independent connection to the main pipe system. Moreover, each fixture should be separately and safely trapped.

There is an endless variety of plumbing appliances obtainable from manufacturers or dealers, but the range of selection becomes quite limited when a few of the leading requirements are considered. It is hardly necessary to say that the material of the fixtures should be strong and durable, non-absorbent and non-corrosive, and the interior surfaces highly smooth and free from corners which readily become befouled and which are difficult to clean. All unnecessary complication must be avoided. Convenience and simplicity are the great desiderata for all fixtures. It is well, in particular, to avoid all useless movable machinery liable to derangement and requiring frequent repairs.

All fixtures should be **arranged in an open manner** and without the commonly followed method of encasing fixtures with tight woodwork.

All concealed overflow channels should be avoided as being difficult to flush and hence liable to accumulate and retain foul slime, which readily putrefies and causes annoying smells. The same applies in a lesser degree to safe drip pipes. The fixtures should one and all be arranged without any hidden or inaccessible overflow pipe, yet be constructed in such a manner as to remove with safety any accidentally overflowing water.

The fixtures which I recommend and prefer to use differ from those commonly chosen in having unusually **large** waste outlets, so as to give a free and quick discharge and to cause a thorough scouring

of the waste pipes attached to the fixtures. The pipes, on the contrary, and the traps attached to them, should be of a **smaller** bore than it is usual to make them. In this way only can the fouling and subsequent stoppage of waste pipes and traps be ultimately and efficiently prevented. The arrangement advocated is quite the opposite of what is considered proper by the majority of architects, builders and plumbers, who still prefer to use fixtures which have small outlets, obstructed by strainers, and which empty through large branch pipes and through possibly still larger traps into the main drainage channel.

In order to still further insure the complete scouring of the interior of waste pipes, I endeavor to avoid the usual trickling flow from fixtures by advocating and selecting certain types of appliances arranged so as to constitute small flush tanks; that is to say, those in which all water can be retained until a large volume accumulates, when it is sent with great velocity through the pipes. This refers in particular to sinks and basins. In the case of water-closets, slop-sinks and urinals, the separate flushing cisterns fitted up with the fixtures accomplish the perfect cleansing and scouring of the fixture, trap and waste pipe. In the words of an eminent sanitarian:

> "At every point the water used for the transportation of the wastes that are to pass through the pipes should be used in the most effective manner. A thread of water running from an imperfect faucet is practically of no value whatever. The watchword of our best present movement is the word '*flushing.*' After pipe ventilation the great secret of good drainage lies in the use of abundant volumes of water delivered in a mass along with each contribution of filth. A perfect system of drainage and water supply would be one where at all ordinary times not a drop of water flowed through the outlet channels, only occasional dashes of several gallons lubricating the walls of the pipes, and carrying along completely and with velocity substances which, under the old system, smeared their sluggish road along the pipe, and left material for infectious decomposition behind."

It is quite evident that to obtain security in a system of house drainage and plumbing, the aim should be to entirely remove through the fixtures, whether the water-closet, the wash basin or the sink, the inevitable production of waste matters *before decomposition sets in*, for in the same degree as the decomposition proceeds, the offensiveness increases and with it the risk of entrance of dangerous gases of putrefaction.

A Few Words on House Planning, with Reference to Comfort and Convenience in Houskeeeping.

No matter how careful attention an architect devotes to the domestic needs and requirements of a household, he is seldom able to grasp all the smaller details which make up in particular woman's sphere. By combining architectural skill and woman's practical common sense, the plans of a house may be admirably contrived, every inch of available space properly utilized, particular attention given to the avoidance of dark corners or inconvenient stairs, and the rooms and closets provided with ample light. Everything which increases **home comfort** should be duly considered. The convenience, prospect and aspect, privacy and best distribution of rooms; warmth, ventilation and light; the avoidance of damp cellars and foundation walls and of leaky roofs, — these and other points combined tend to make a dwelling not merely a shelter against the elements, but a beloved spot where housekeeping may be a source of constant pleasure and infinite enjoyment.

The **servants' quarters,** comprising the kitchen, scullery, storeroom, laundry and pantry on the lower floors, and the housemaid's closet and servants' bedrooms on the upper floors, should be grouped conveniently together, yet be placed, if possible, so as to be shut off from the main part of the house. A direct communication can be established between the lower and the upper floors by means of a convenient service staircase.

A roomy **linen closet** should be provided on one of the upper floors of every house. This closet or compartment should, where practicable, be warm and dry, and therefore its position should not be against an outer wall. It is well, where space is available, to have near it a separate well-lighted and airy closet for the storage of the soiled family clothes. Wide shelves of enameled wood or of slate, which can be frequently washed, serve for the assorting of the washing, which is taken from there to a lift used for the washing only, and sent down-stairs to the laundry, to be soaked in the washtubs on the night previous to washing day.

Nor should we overlook in our houses measures tending to promote the comfort and health of those whom we expect to work for us. Hence the **servants' chambers** should not be the usually

small, musty holes, which hardly deserve the name of a room, and which are scarcely sufficient in size to accommodate one small bed, a table and a single chair. Servants' bedrooms, particularly where a separate servants' hall has not been provided in the plans, should be of ample size and comfortably fitted up, so as to be also a sitting-room where the servants may escape from the heat of the kitchen and rest after the performance of their daily household duties. The room should have a pleasant outlook, good ventilation, ample light and closet space. To quote from Robert W. Edis, an English architect:

> "I cannot too strongly insist upon the necessity of making those about us as comfortable as possible, for I am quite sure that, if we provide comfort and health for them, they will be much more capable of doing their daily work fairly and acting well by us. Remember always that a large proportion of their lives is spent absolutely underground, and that it is essential that they should have at least one room which shall be cheerful, well ventilated, and as pleasant as we can make it. Put yourselves in their places, and do as you would be done by, and so far as my experience teaches me, I am morally certain that the master or mistress who provides well-lighted apartments for them to live and sleep in will be more certain of keeping good servants, and of obtaining good work from them. If they are to be mewed up in ill-ventilated, uncomfortable and unhealthy chambers for the greater part of their daily lives, you can hardly expect their work to be properly done; the atmosphere in which they live will enervate them and make them comparatively useless."

The Kitchen.—Nowhere else, perhaps, does careful planning secure such good results as in the servants' department, and particularly in the **kitchen.** The proper arrangement of this room has a well-known bearing upon the future comfort and happiness of the inmates of a dwelling-house. Hence efforts should be made to render the kitchen not a mere dismal place, where cooking and washing are performed, but an attractive, convenient and bright spot, a sitting-room, as it were, for the domestics.

The kitchen should be of a sufficient size to permit the convenient performance of the cooking operations; it should be neither too narrow and crowded nor of too large dimensions. Windows on opposite sides of the kitchen to allow of cross-ventilation in the

summer time are desirable, but obtainable only in those houses which stand detached.

There should be plenty of closet room and abundance of shelf space; in other words, the kitchen should be arranged in accordance with the old saying: "A place for everything and everything in its place."

In order to avoid as much as possible the nuisance incident to "washing day," the **kitchen** and **laundry departments should not be combined.** Ordinarily, owing to lack of space, and partly also to reduce the labor of the one servant, who is obliged to do both the cooking and the washing, these are, at least in the smaller private houses, combined in one room. If there is anything which may be said to disgust the feelings of any person at all fastidious, it is the atmosphere of an ordinary kitchen on the day when washing is being done. The whole room seems on such occasions to be filled with a mixture of vapors arising from the cooking of food on the range and from the boiling and soaping of the soiled family clothes and bed-linen, all more or less saturated with the waste excretions from the body. These volatile elements attach themselves to the furniture of the kitchen, cling to the walls, ceilings and floors; they, unfortunately, often penetrate to the front hall, staircase and the livingrooms and bedrooms, and announce to any casual visitor at the front vestibule the fact that washing is being done. A thorough removal by **efficient ventilating flues** of both the cooking fumes and the vapors from the wash-boiler should be insisted upon. The best remedy, doubtless, consists in having a laundry entirely separate from the kitchen, both of them being ventilated in the best possible manner.

The Kitchen Sink.—In taking up the discussion of the fixtures let us begin with the **kitchen sink,** which is one of the most indispensable outfits of a well-appointed kitchen. Unless a special scullery is provided, the meat and vegetables are washed and prepared for cooking in the kitchen sink; it also serves for the washing of the cooking utensils and dishes after meals.

The sink receives much of the **kitchen grease,** and this gives rise to the principal difficulty in dealing with this kind of plumbing fixture. The grease usually passes through the sink strainer dissolved in hot water, and therefore in a fluid condition. It

soon chills, however, becomes more or less solid, attaches itself to the walls of the waste pipes and traps, especially where these are of too large caliber, and becomes hard. Thus it sooner or later causes annoying stoppages.

This difficulty is well known to most householders, and to avoid it careful housewives are in the habit of saving as much of the grease as possible instead of pouring it out into the sink, while in large houses it is quite usual to employ a device of some form or other, technically called a **grease trap,** which is intended to arrest the grease before it passes into the waste pipes. To prevent the occurrence of obstructions in the sink pipes it is also a common practice to pour a hot solution of potash or lye through the pipes, which dissolves, at least to some extent, the grease and thereby cleanses the pipes and traps. All grease which remains for any length of time attached to the pipes undergoes a rapid and very offensive putrefaction, but this fact is apt to be overlooked by householders. It thus becomes the sanitarian's duty to lay particular stress upon this matter and to point out that dangers to health may lurk in the kitchen sink pipe not less than in the water-closet drain.

In small houses, and wherever care is taken to save the grease, a plain kitchen sink may answer all purposes. The usual material for sinks is cast iron, and its surface is sometimes protected from rust either by painting, galvanizing, enameling or by the Bower-Barff process. Paint soon washes off, the galvanized coating wears out, and the enamel or porcelain lining is apt to crack or scale off. Plain iron sinks can be kept entirely free from rust, provided they are in constant use.

Much the best, brightest and cleanest material, however, for kitchen sinks is white earthenware or solid stoneware. Such sinks are now readily obtainable of all sizes and shapes; they are supported on bronzed or galvanized iron or brass or white porcelain legs, and are provided either with a hardwood or still better with a glazed roll-rim, doing away with all woodwork (Fig. 39). The sink should have a marble or porcelain back to protect the wall from splashings. Some sinks are manufactured with integral back, thus avoiding the rather objectionable joint between sink and back.

Other kinds of sinks, such as those of plain wood, or wood lined with lead, zinc or copper, and those of slate or sandstone, have

gradually gone out of use. Sinks made of soapstone are still employed, especially in the New England States, but they soon acquire a black coloring owing to the grease absorbed in the grains of the

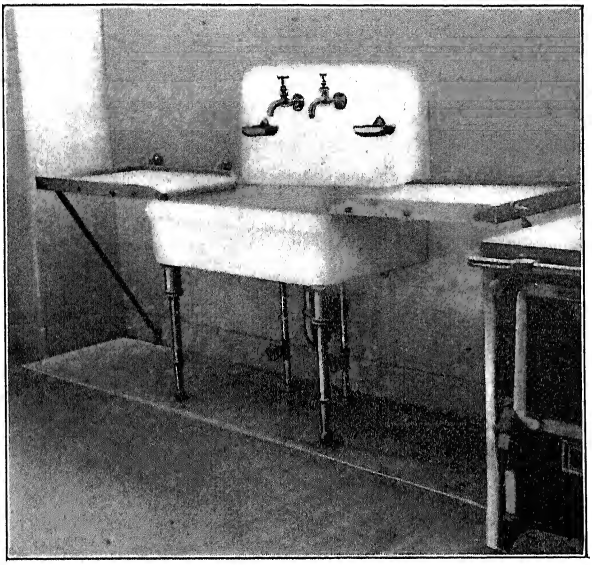

FIG. 39. View of a Solid Porcelain Kitchen Sink.

stone, which renders their appearance far from inviting. Nothing surpasses in purity and beauty a white all-porcelain sink, with molded edges, the sink being made strong enough so as not to crack or break.

If such a sink is used, it is quite important to have its outlet protected with a strong polished or plated **brass strainer, securely fastened** to the sink, otherwise servants will frequently remove the strainer and brush all kinds of solid refuse into the pipes, which will cause frequent stoppages and a never-ceasing demand for the "family plumber." Since it is the usual practice in washing dishes to set into the sink a wooden vessel filled with water, which is quickly emptied after use, the waste pipe and trap receive at frequent intervals a reasonable amount of scouring, provided the pipe and trap are restricted in size so as to concentrate the flushing water. For some reasons I prefer a form of kitchen sink having a standpipe

overflow in place of an open strainer, and in which water can be held.

Grease Traps for Sinks.— Where much grease is wasted, it is customary to use a **grease trap** with the kitchen sink. My experience with several kinds of grease traps has led me to discard all those attached to the sink, or located close to the sink, or else placed in the basement, and intended to arrest and retain the grease. It is a most difficult matter to get the cook to attend to the removal of the grease at frequent intervals, and the cleansing of the grease chamber is thus generally neglected. Hence the grease traps actually soon turn into a noxious cesspool within the house, and if, finally, water refuses to flow off freely, the removal of the putrefied grease causes an abominable nuisance.

A grease trap of stoneware or built of brickwork, located outside of the house, not too far away from the sink, — for otherwise the grease would solidify before it would get to the grease trap, — is much less objectionable than the usual indoor appliance.

A device, attached directly underneath the sink which was invented by the late Col. George E. Waring, Jr., seems to answer the requirement of preventing the grease from clinging to the inside of the waste pipes, besides insuring a good flush to the trap and its waste. This apparatus is called the **flushpot,** and it can be attached to kitchen sinks of iron, soapstone or porcelain. It is illustrated in Fig. 40, and to describe it I cannot do better than quote the words of the inventor:

> "The flushpot is an entirely new departure. It holds back everything, water and all, until it is filled. The pot under the sink holds six or seven gallons. Its contents are then discharged — the whole volume suddenly — with such flushing force as to prevent adhesion to the walls of the waste pipe. It is entirely simple in its construction and needs no special thought. When the water ceases to run from the sink, the cook knows she must lift the plug *a* of the flushpot, by means of knob *c*. The strainer *b* may be easily removed at will. The whole interior, when exposed to view, is within the easy reach of a clout or a wisp, so that it may be kept as clean as a soup kettle. We thus secure the *entire removal* of the whole of this greatest source of foul decomposition *before its putrefaction begins.* In discharging the flushpot, the handle should be raised only until the stop strikes the lower side of the strainer. The strainer should not be removed except for cleansing. *It should never be removed while refuse of any kind is in the sink.*"

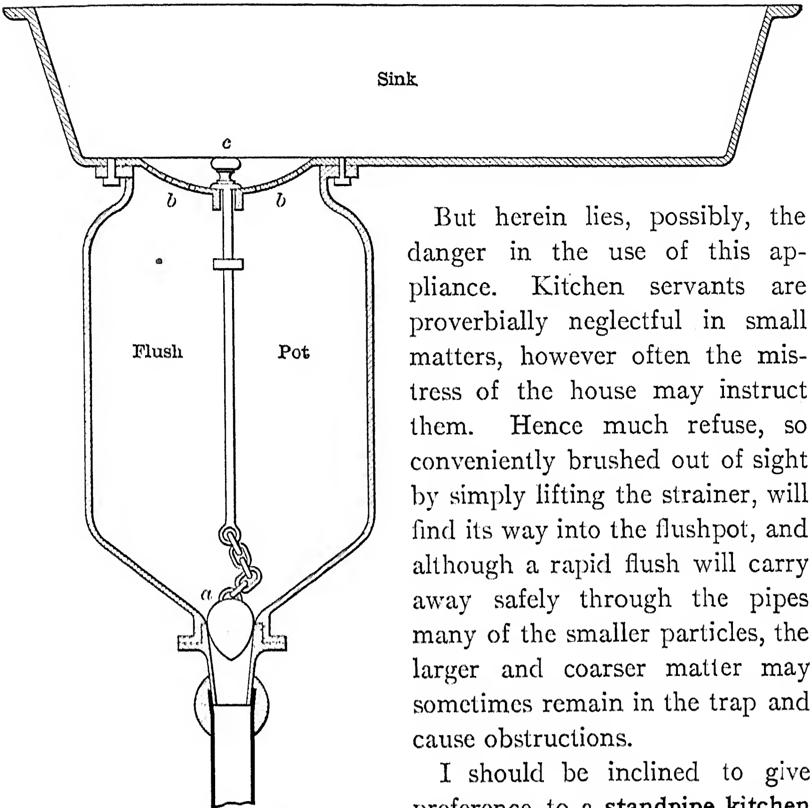

FIG. 40. Section of Kitchen Sink with Flushpot.

But herein lies, possibly, the danger in the use of this appliance. Kitchen servants are proverbially neglectful in small matters, however often the mistress of the house may instruct them. Hence much refuse, so conveniently brushed out of sight by simply lifting the strainer, will find its way into the flushpot, and although a rapid flush will carry away safely through the pipes many of the smaller particles, the larger and coarser matter may sometimes remain in the trap and cause obstructions.

I should be inclined to give preference to a **standpipe kitchen sink,** which I once devised and suggested as a modification of the flushpot. (See Figs. 41 and 42.) The sink shown in the illustrations in plan and section is divided by a vertical partition wall *a* into a shallow and a deep part. The shallow sink *A*, with slightly inclined bottom, is used in the same manner as ordinary sinks are. The water flows from it into the deeper receptable *B* through a vertical strainer in the partition *a*, which strainer retains all the coarser refuse. This is conveniently gotten rid of by being burned in the range. Whenever the deeper receptacle is filled to the overflow line of the standpipe *b*, the cook lifts the latter by means of a knob *c*, and the discharge is effected in exactly the same manner as that of the flushpot described above. The deep receptacle *B* may gradually accumulate greasy slime, but this can be readily

prevented by frequent cleansing, which is easily accomplished, because the vessel is left entirely open. Nor is it difficult to lift or cleanse the standpipe as often as may be desired. The deep recep-

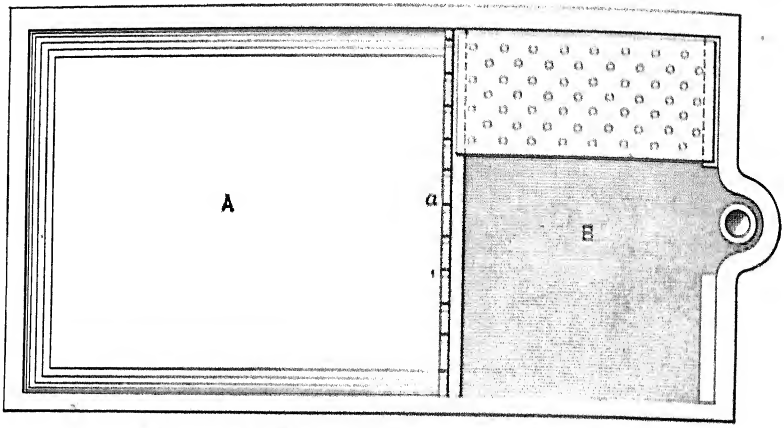

FIG. 41. Plan of Sink with Standpipe and Flushpot.

tacle serves a further useful purpose in case it is desired to wash the utensils, pots, dishes, etc., directly in a vessel holding a great volume of water. The sink can be made of iron, but a slight

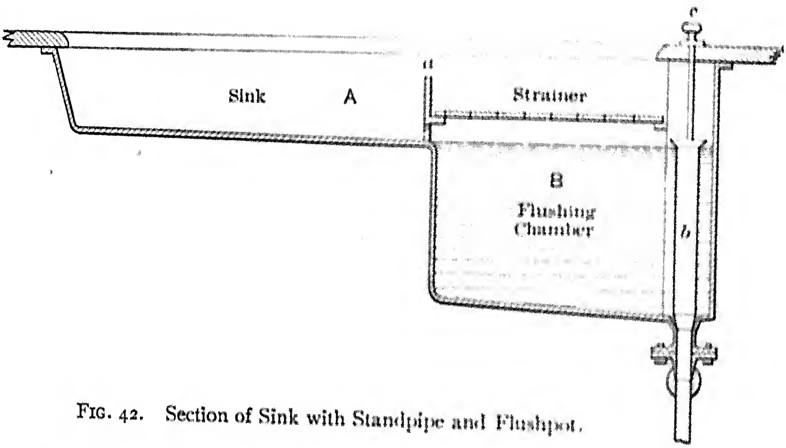

FIG. 42. Section of Sink with Standpipe and Flushpot.

modification renders the device equally applicable to the ordinary earthen sink. A sink constructed on this principle, but modified somewhat, was manufactured and sold some years ago by the Sanitas Manufacturing Company of Boston.

Walls and Floors of Kitchens. — As regards the immediate surroundings of kitchen sinks, I advise that under no circumstances should a sink have any enclosure of woodwork or cupboards serving as a storage place for rags, kitchen utensils, and all kinds of dust and dirt. Let everything be kept open and in plain sight. The **walls of the kitchen** to a height of at least five feet should be lined either with marble or with white enameled tiles. Their bright, non-absorbent and easily washed surfaces add much to the beauty and cleanliness of a kitchen, besides measurably increasing the light of the apartment.

Concerning the **kitchen floor,** it is desirable, from a sanitary point of view, that it be made impervious to moisture. Concrete, mosaic tile or terrazzo floors are decidedly to be preferred to wooden floors. Directly under the kitchen sink and in front of the range white glazed tiles may be laid. Sometimes a long slab of marble is put on the floor where the sink stands. Should wooden floors be used in the central portion of the room, they should be constructed of smooth and narrow strips of board of the best hardwood, saturated with hot linseed oil, and well rubbed to give the surface a bright polish.

The Kitchen Range and Boiler. — Another plumbing fixture of importance in the kitchen is the **hot-water apparatus,** comprising the water back of the **range** and the **kitchen boiler.** The latter term is evidently a misnomer, since the boiler is simply a reservoir for hot water, while the water back actually constitutes the boiler. Very little of sanitary importance can be said concerning them. The proper way of fitting up kitchen boilers is discussed in detail in the chapter on "Domestic Water Supply." For details about **kitchen ranges** the readers are referred to the author's book, "Kitchen and Laundries," Chicago, 1910.

The Butler's Pantry. — Adjoining the dining-room, and in the case of country houses conveniently placed between it and the kitchen, we find in the better class of houses a **butler's pantry** and china closet. This apartment should contain plenty of shelf room and cupboards for the finer china ware and for glasses. It should also be fitted up with a good-sized **plate-warmer,** heated by hot air or by steam, taken from the house-heating apparatus, or else by a gas-burner. Quite recently plate-warmers heated by the electric current have come into use. Sometimes the pantry contains a **small refrigerator** for the

keeping of butter, jelly, or a few wine bottles (Fig. 43). Plenty of space should be provided near the window for a *pantry sink*, in which cups, glasses, plates and fine china are washed. The sink should be supplied with hot and cold water, and have a large and convenient draining shelf.

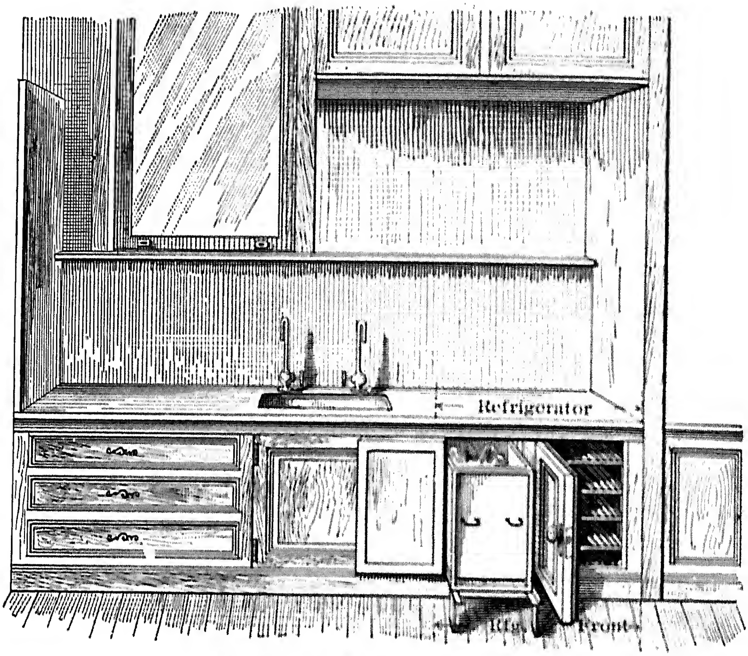

FIG. 43. A Pantry Refrigerator.

The Pantry Sink. — The usual **material** chosen for pantry sinks is tinned and planished copper. This is preferable to enameled cast iron and also to earthen or porcelain sinks, as it avoids the frequent breakage of the glass and china ware. Copper sinks are made in all sizes, either with a flat or else with an oval bottom, the former being preferable, as dishes do not slide in them as they do in oval sinks. The ordinary forms of sinks are provided with an outlet placed in the center or at one end of the sink bottom. The outlet is closed with a plug attached to a chain, and hence an overflow pipe must be arranged. Occasionally such sinks are fitted up with a waste-cock or waste-valve, closing the outlet pipe and thus retaining

water in the sink. In this case, too, the usual overflow is arranged concealed, though sometimes the waste-valve is constructed so as to act as overflow pipe.

I am not in favor of either arrangement and believe that a much simpler and in every way better device consists in a pantry **sink with standpipe overflow.** This does away with both the many easily befouled links of the chain and with the nuisance arising from the common overflow pipe, which being inaccessible is difficult to clean, and never has a powerful flush of water through it, but merely occasionally a trickling stream. The plated brass standpipe serves at once as a plug to close the outlet when water is to be retained in the sink, and also as an overflow pipe in case the water should be accidentally left running at the faucets. A standpipe can be easily lifted and readily cleaned, and when arranged in a recess of the sink it is not in the way in washing dishes.

Such pantry sinks are made either of tinned and planished copper, of at least twenty-four ounces' weight per square foot, or else of the more expensive German silver or white metal. The most serviceable, though rather expensive, sinks are those made with two compartments, one for washing, the other for rinsing. All sinks should have a large outlet, protected by a strainer.

A convenient arrangement is what is known as the "Sanitas" pantry sink, in which the standpipe is provided with a simple cam movement to lift it from its seat when it is desired to empty the sink. The volume of water discharged from a sink with large outlet is concentrated beyond in the smaller trap and waste pipe, causes a thorough flushing of both, and prevents the grease from the dishes from adhering to the sides of the pipe.

Another device having the latter object in view is the ordinary copper pantry sink with copper flushpot of small size attached to its underside. The flushpot is similar to the one shown in Fig. 40 and holds about a gallon of water. The operation of the fixture is the same as that of the flushpot described for kitchen sinks.

A pantry sink should always be arranged **free from all tight enclosure,** so that the space under the sink, the floor and the rear wall may be entirely exposed and accessible to the broom and dust brush of the servant. (See Fig. 44.) The **floor** should be finished in tiles or in marble, as ought also to be the walls, in preference

to the usual wooden wainscoting. The sink should have a back of marble to prevent splashing against the walls. Concerning the top finish of the sink, I would say that although it is quite customary to cover a pantry sink with a marble slab on account of its cleanly appearance, I prefer using a **hardwood draining-shelf,** the wood being well seasoned, and well filled previous to use, and arranged with a number of inclined grooves to allow the water dripping from glasses or cups after rinsing to drain away into the sink. Much of the usual breakage of china ware by careless servants will thus be averted. A still better, though much more expensive, drain-board

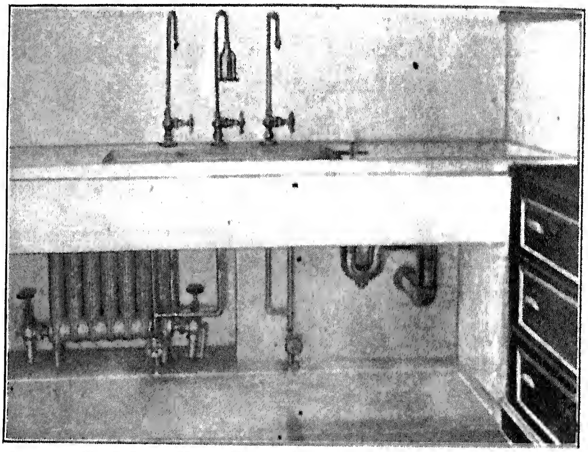

FIG. 44. View of Pantry Sink.

is made in German silver metal, and is combined with the German silver sink, and usually also comprises a metal splash-back.

The Refrigerator.—A large **storeroom** should be planned off the kitchen, preferably on the cool side of the house, for the keeping of the kitchen supplies. The **refrigerator** may be placed in this room. There is always some danger of the food supply or the milk becoming tainted and unfit for use by even slight contaminations of the air in the store-closet. Accordingly, special pains should be taken to have this apartment well ventilated by a window admitting plenty of light and a direct supply of pure air from outdoors, at least in summer time.

Absolute cleanliness should be the principal feature of the store-

room. The walls should be tiled to the usual height of the wainscoting, while above it the walls, as well as the ceiling, should be finished with a rendering of smoothly polished cement which may be enamel painted, so as to be perfectly non-absorbent and readily washed and cleaned by means of a sponge. Woodwork should be avoided as much as possible. All shelves should consist of slate, of marble or of annealed glass.

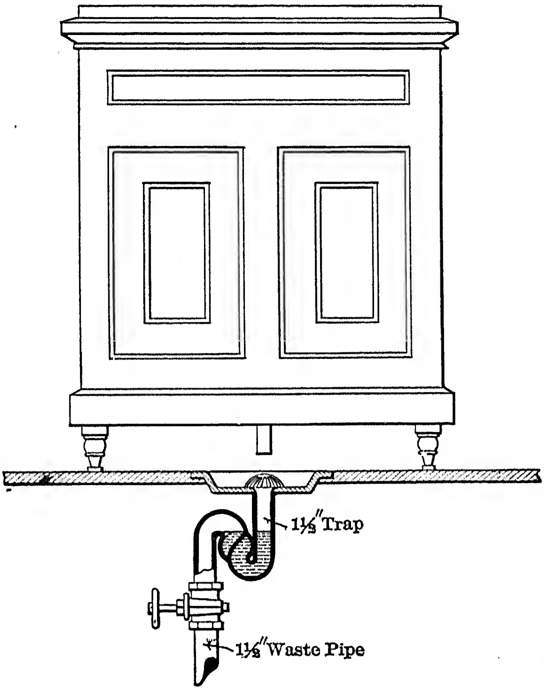

FIG. 45. Arrangement of Refrigerator Waste Pipe.

There should not, of course, be a direct connection between a refrigerator and a soil or drain pipe. In small households a pail may be placed under the refrigerator, to be emptied as soon as filled by the drippings from the melted ice. But, wherever the demands of the household require a rather large quantity of ice, the manual labor involved in the frequent removal of the pail is quite considerable, and overflows will, in all likelihood, occur at times. It is therefore usual to carry the refrigerator waste over

a securely trapped sink placed in the basement or cellar. The **refrigerator waste pipe** should be at least 1½ inches in diameter, and provision should be made for frequent flushing. One method of trapping a refrigerator waste pipe is shown in Fig. 45. As shown, the waste pipe has not only an anti-siphon trap, but also a gate valve to cut off the waste pipe entirely when so desired.

The Laundry. — The laundry is a specially important department in the practical working of a household, and its fitting up should be made perfect in all respects. Much valuable assistance may be received, to attain this end, from the counsel of an experienced housekeeper, for no man can know the practical details of household work better than a woman does.

The **laundry room,** as already indicated, **should be** entirely **separate from the kitchen,** and located so as to avoid the free distribution of laundry vapors throughout the whole house. Where the means permit doing so, a further subdivision may be made by arranging a separate washing-room or laundry and an ironing room, combined with a drying-room. As a rule, however, both the washing and finishing operations are performed, in private residences, in the same room.

Sometimes this room is put on the top floor of the house so as to avoid the nuisance of soapy smells and vapors of steam pervading the house. A part of the attic can then without difficulty be transformed into a drying closet. But the location adjoining the kitchen undoubtedly simplifies the question as to the water supply for the washing tubs, as to the chimney flue required for the wash-boiler and as to the ventilation of the apartment; it also does away with the possibility of damages to ceilings caused by the tubs overflowing.

Washing Operations. — The **washing operations** consist in the preliminary washing of the soaked linen, in the boiling with lye or soda, in the washing proper, the rinsing, bluing (for cotton and linen only) and the wringing of the clothes.

To be conveniently performed, washing requires a set of usually three, but sometimes four, stationary **washtubs,** each supplied with hot and cold water, also a copper wash-boiler and a small **laundry sink.** On dry and sunny days the washing is dried and bleached out of doors, in the case of country houses on a plot of grass land or a well-kept lawn situated at the rear of the house,

sheltered from view, yet well exposed to the wind currents. But to avoid the frequent delays in the laundry caused in the rainy season or in winter time, a drying-room is usually provided in city houses and arranged in the basement, or else in the cellar, in which case it may be connected with the laundry by a dumb waiter. This may also be continued to the upper floors and used to send the finished linen upstairs. Such a drying-closet is particularly convenient in those city houses which have only a small back yard.

The **drying-closet** is provided with a number of upright frames or "horses" for hanging up the wet linen, the horses being suspended from and sliding on rollers, so as to be easily pulled out or pushed into the drying-closet. The closet has either coils of steam pipe, supplied with steam from the house boiler, or else it is heated with hot air or gas, and due provision is made for a strong circulation of air by vent flues for removing the moisture due to evaporation. In a special form of laundry drier the heat from the laundry stove is utilized for drying the clothes.

The finishing operations, viz., the starching, ironing and mangling, if performed in the laundry, require one or two ironing tables placed in front of a window and sometimes a small hand mangle.

In a laundry much heat and moisture are constantly and unavoidably present; the laundress cannot help spilling from the tubs more or less water; annoying and even noxious vapors of steam are generated at the boiler as well as at the tubs, all charged with soapy slime and more or less organic filth; moreover, an often unbearable heat and bad odors are present when ironing is being done; hence the **ventilation of the apartment** and the construction of its floors, walls and ceilings require the most careful attention.

Woodwork must be avoided as much as possible, and preference should be given to non-absorbent substances, — enameled bricks, glazed tiles, or plain, smooth cement. The **floor of a laundry,** at least where the tubs stand, should be made perfectly waterproof. In large laundry establishments it appears desirable to have a direct removal from the floor of all superfluous water through trapped pipes and floor drains connecting with the house sewer, but such a complication is unnecessary in private residences, where it is easy to take up with a mop or a sponge what little amount of water is spilled,

and to remove it in a pail. An asphalted, cemented, marble or flagstone floor is suitable for large washing-houses, but for a small house laundry nothing can surpass in cleanliness and beauty a floor laid wholly in white unglazed or vitrified tiles. A good floor consisting of rubber interlocked tiles is used to some extent in modern dwellings. The **walls** can be **made damp-proof** by being laid with enameled bricks, or else glazed tiles may be used to the height of the wainscoting, the remaining upper part of the wall being smoothly rendered in cement or oil-painted. It is desirable that the **ceiling,** too, be rendered as **impervious** as possible, for much of the noxious steam vapor will rise and cling to it, notwithstanding the best ventilation.

Among the fixtures of a laundry we often find a boiler of tinned copper which is used for boiling clothes. It is set by the mason in brickwork, and is supplied by the plumber with cold water and with emptying bib. It has a grate for the fire below, and is also provided with a suitable space for heating flat irons. An essential arrangement is a ventilating pipe carried from the kettle to a heated flue to remove, when the clothes are boiled, the bulk of annoying steam vapors.

The Laundry Tubs. — The most important fixture to be provided in a laundry is a set of **stationary washtubs.** Wooden laundry tubs are out of the question on account of their perishable character, their liability to rot, and because of sanitary objections. Iron tubs are usually considered objectionable owing to the possibility of imparting rust stains to linen, though this latter objection does not apply to the best grades of enameled iron tubs. The choice therefore rests between tubs of cement, soapstone, slate, porcelain-lined iron, and earthenware.

The solid porcelain tubs surpass all others in durability, fitness and neatness. Each porcelain tub is molded and glazed in one piece, is perfectly non-absorbent, easily washed with a sponge, and conspicuous for its brightness and purity. The tubs are usually set in front of or near a large window, so as to have the best light available for the washing operation. All tubs should be fitted up in an open manner; the usual baseboard, hiding the plumbing work under the tubs, should be omitted, likewise the wooden covers. However useful covers may be for tubs located in small apartment-house kitchens, to make the top useful as a table, it is decidedly prefer-

able in a laundry to let the air have free access to the inside of the tubs. The tubs are set in a framework supported by galvanized, bronzed iron or porcelain legs of graceful shape.

The top of the tubs is sometimes fitted up with a hardwood rim, to which the wash-wringer can be clamped, but the best sanitary tubs

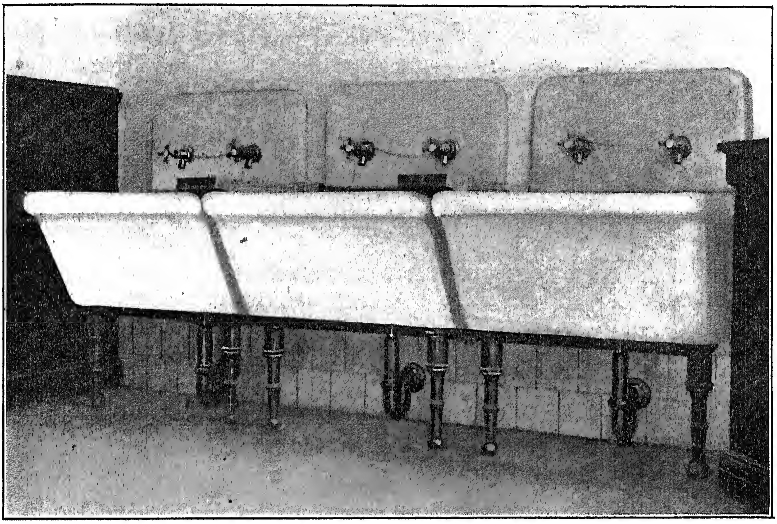

FIG. 46. View of Laundry Tubs.

have molded and glazed roll-rim edges, and the wringer can be attached to a detachable wringer board. (See Fig. 46.) Each tub has hot and cold water, the former drawn either from the kitchen boiler or from a special laundry boiler, and both supplied by

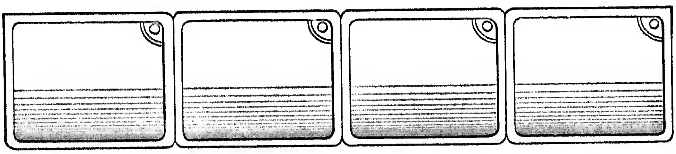

FIG. 47. Plan of Set of Washtubs.

faucets placed over the top of the tubs. This arrangement of the faucets gives more room in the tubs for the clothes to be washed. In place of the chain and plug a standpipe overflow may be used, as shown in plan and in section in Figs. 47 and 48, thus avoiding not

only the danger of an accidental overflow, but also, what is more important, the common nuisance of soapy slime and particles of filth from soiled linen adhering to the countless links of the chain.

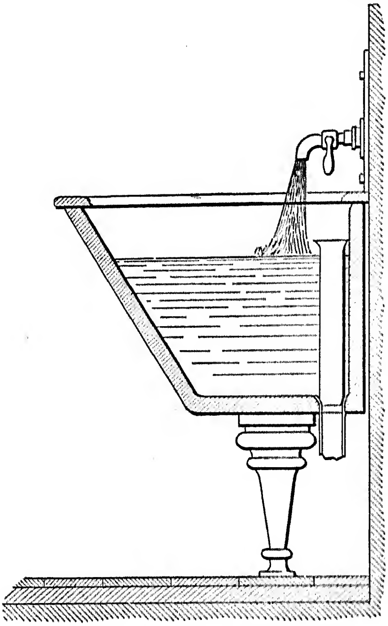

FIG. 48. Section of Washtub with Standpipe Overflow.

The Laundry Sink. — Nowhere in the laundry should any plain iron be used, for this causes rust stains in the washing. Therefore if a **laundry sink** is required, it should be of either porcelain-lined iron or of white glazed earthenware to match the whole appointment of the room. It should be set on brackets strongly fastened to the wall, or on legs, the space under the sink being left entirely open and the entire arrangement being similar to that of the kitchen sink. The sink should have hot and cold water faucets and a large outlet with a suitable strainer, and in place of the chain, plug and hidden overflow pipe a nickel-plated standing overflow.

The Servants' Water-closet.— Adjoining the laundry or else near the kitchen, a water-closet, or a **toilet or bath-room for** the use of the **servants,** should be arranged.

There are decided objections against placing the servants' water-closet in the cellar. Sometimes a servants' bath room is arranged on the top floor, near the servants' bedchambers, but in such case an additional water-closet is required not too far from the kitchen and laundry. Ample light and free access of air should be given to the closet by means of a good-sized outer window, and all possible precautions should be taken to avoid uncleanliness.

Concerning the general arrangement of the servants' water-closet, it should be remembered that this apartment is least likely to be periodically inspected by the head of the household, and hence slovenliness and dirt accumulation are much more apt to exist

here than anywhere else in the house. Every possible aid should be given to induce clean habits of the domestics. In the majority of houses any corner, no matter how dark, ill ventilated or out-of-

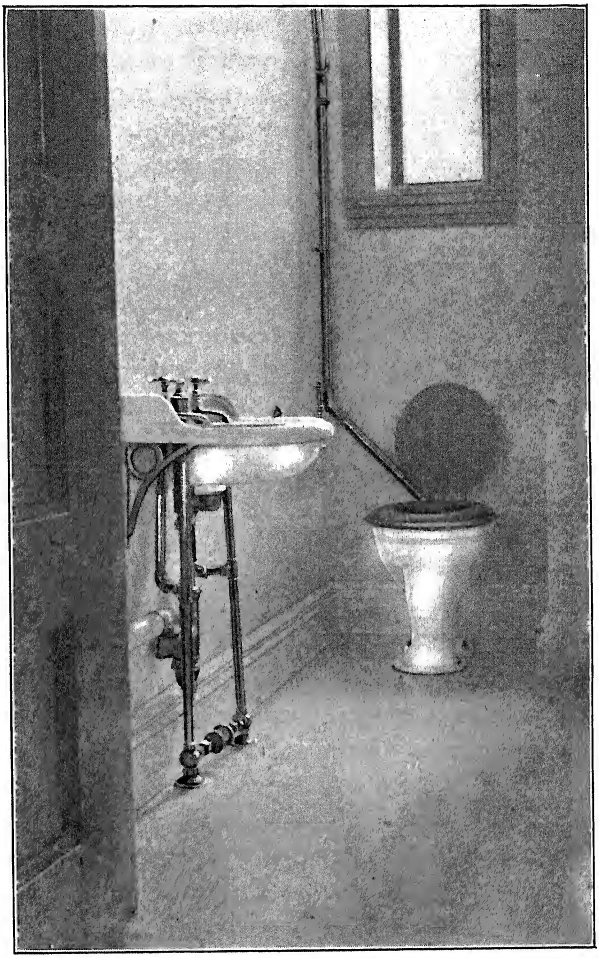

FIG. 49. Servants' Toilet Room with Water-closet and Washbasin.

the-way it may be, is considered a good enough place for the servants' water-closet, and the usual practice is to select and place in it the cheapest and generally the worst kind of apparatus. It is hardly possible to make a greater mistake, for here, if anywhere,

perfection of the fixture and the greatest simplicity of arrangement are required.

The usual tight closet enclosure should be abolished, and the riser as well as the useless cover of the seat should be done away with. Complicated mechanical apparatus with pulls and cups, wires and cranks, levers and rods, valves and chains, all liable to frequent derangement, especially if used by careless servants should not be tolerated. The seat should be arranged in the plainest way and entirely in an open manner. Often the closet is fitted up with only a narrow round seat, resting on the bowl which is constructed of sufficient strength to sustain the weight of the person. The seat is fastened either to the porcelain bowl or to a wooden cleat, and is hinged in such a way that it may be lifted and turned against the back wall, completely exposing the earthenware closet. Thus arranged, the closet may serve as a convenient urinal as well as slop-hopper.

The closet may stand on a floor of white tiles, and the walls may be similarly finished and rendered damp-proof. If thus arranged, the whole space is easily kept clean and neat. The remotest corner is readily accessible to the broom and the dust cloth, and the floors and walls may receive a daily washing with a sponge, soap and hot water. A neatly arranged servants' toilet room, containing a water-closet and a convenient though small lavatory, is shown in Fig. 49.

The Servants' Bath. — Cleanliness of the body is essential to the health of all individuals. Hence it follows that a **servants' bath tub** should be looked upon not as a luxury but as a necessity in even the humblest home. In fact, no house should be built without one, and fortunately, in its simplest arrangement, it does not cost much to provide for it. Its utility is much increased by arranging it so that it may be readily supplied with hot water, and by placing it in a moderately heated apartment, so that it may be used at all seasons of the year. A good housewife will always consider the needs of her servants in this respect and provide, at least where economy in building construction is no hindrance, a simple bath tub for their use, so as not to afford them any excuse for slovenliness, uncleanness or untidiness in personal appearance.

To simplify the arrangement of the plumbing work, the servants'

bath may be located in the attic, directly above the principal family bath room or else it may be placed near the kitchen or even in the laundry. An iron bath tub, smoothly enameled on the inside, or else a steel-clad copper tub, resting on four short legs, thus leaving the floor space under the tub entirely free and accessible, is a serviceable appliance. The tub must be supplied with hot and cold water, delivered into the tub at its top through a mixing nozzle.

In place of the usual plug and chain, a nickel-plated standpipe, *a*, may be inserted into the outlet of the tub (see Fig. 50). If

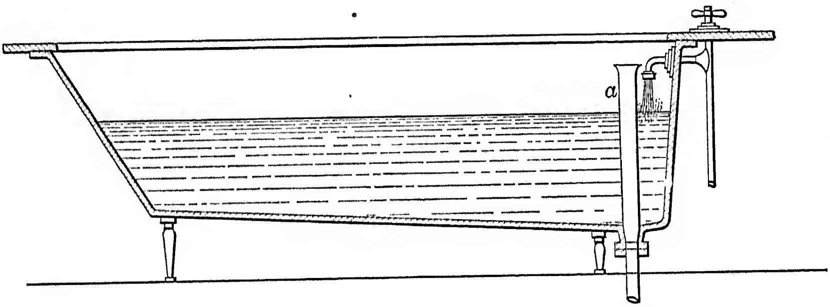

FIG. 50. Section of Bath Tub with Standpipe Overflow.

water reaches the level of the top of the standpipe, any additional flow is taken care of by the standing overflow, which carries the surplus safely into the waste pipe. To discharge the contents of the bath, the standpipe is removed and laid on strong hooks fastened to the wall, and the bath tub is then rapidly emptied, the whole volume of water flowing with great force through the outlet and thoroughly scouring the trap, the waste pipe and the main soil pipe. The usual hidden overflow is avoided and with it a common cause of noxious smells in bath rooms. There is but one objection to such an arrangement, and that is that the standpipe is somewhat in the way of the feet while bathing. A better arrangement, which entirely overcomes this slight drawback, is the bath tub with standpipe placed in a recess but so as to be perfectly accessible for cleaning. This may be combined with a convenient lifting arrangement for the standpipe, of which several modifications may be found in the showrooms of manufacturers of plumbing supplies.

The Housemaid's Sink. — The **housemaid's sink** is in design, material and detail arrangement similar to, though smaller than, the earthenware sink used for the kitchen or the laundry. This sink is not intended for pouring out slops, but merely to draw hot or cold water for the rooms on the upper floors; it should, of course, have a separate and properly trapped waste pipe.

A few other domestic appliances belonging to the servants' quarters are the slop-hopper, the garbage pail and the dust bin. Of these the slop-hopper will be considered later on under the discussion of sanitary water-closets, while the other appliances belong more properly to the general topic of household cleanliness, into which this book is not intended to go.

THE SANITARY CONSTRUCTION AND ARRANGEMENT OF BATH ROOMS.

The principal bath rooms should be located close to the family and guests' bedrooms, either with a door establishing a direct communication between them or connected with them by a short hall. The **bath rooms** should receive light from an outside window or from a large ventilating skylight. They should be heated from the central heating apparatus in the cellar, and in addition to this they may have an open fireplace or a gas fireplace heater, which forms a pleasing and distinctive feature.

Bath rooms of American houses contain usually three fixtures, a bath tub, a wash basin, and a water-closet. Sometimes other fixtures are added, such as a bidet, a sitz bath, or a shower and needle bath. Frequently I have pointed out the desirability of placing the water-closet in a separate compartment, particularly in houses having only one bath room, but also for apartment houses. I shall not discuss in this place the relative advantages of bath rooms located in the center of the house, with overhead skylight and vent shaft, and of those bath rooms which have an outside window.*

In Figs. 51, 52, 53, and 54 are shown interior views of modern bath rooms which were fitted up in high-class residences under the direction of the writer.

* See Gerhard, Sanitary Engineering of Buildings; also Gerhard, Modern Baths and Bath Houses.

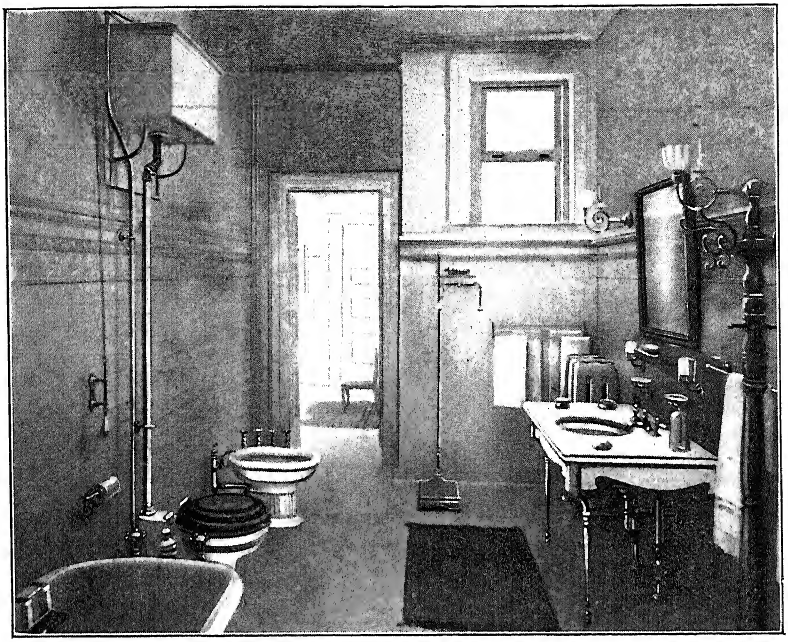

FIG. 51. View Showing Plumbing Fixtures in a Bath Room.

FIG. 52. View Showing Plumbing Fixtures in a Bath Room.

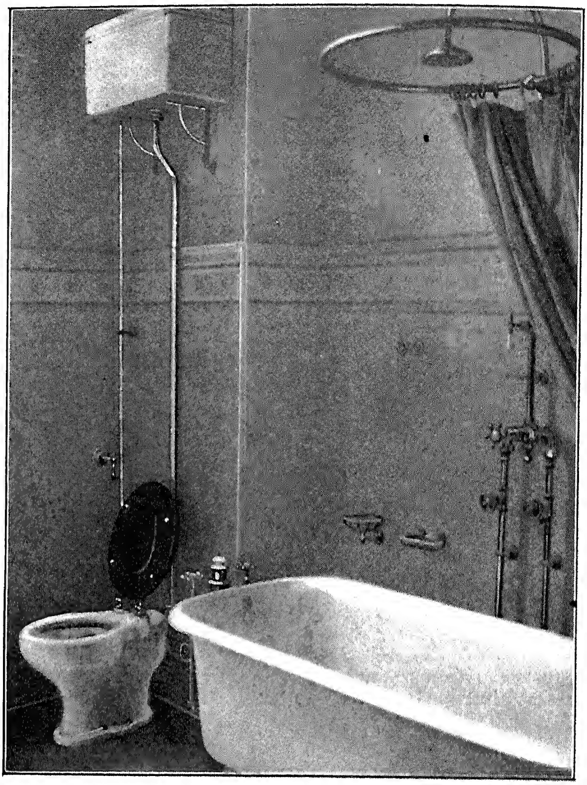

FIG. 53. View of Bath Room Containing Bath and Water closet.

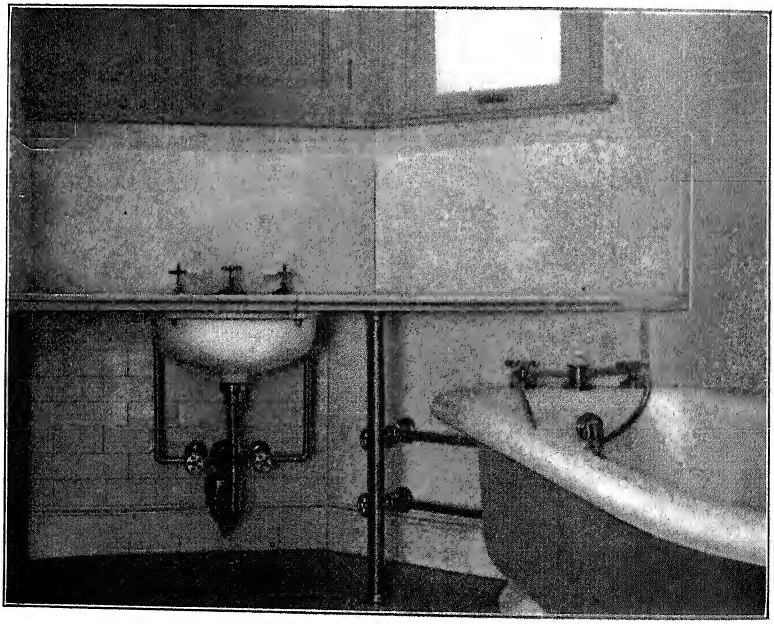

FIG. 54. View of Bath Room Containing Bath Tub and Basin.

Regarding the **arrangement of bath or toilet rooms** in general, the **floors** and the **walls** should be made as much as possible **damp-proof.** No more elegant finish could be devised for the **floor** of a bath room than vitrified white tiles, which are conspicuous for their bright appearance, superior cleanliness and purity. Some people object to a tiled floor, claiming that it causes a feeling of chilliness to the feet of the person emerging from the bath, but this may easily be obviated by having rugs or cork bath mats placed on the floor of the room. A fire in an open fireplace also helps to prevent the sensation of chilliness. Hardwood floors, tightly jointed and well soaked with hot linseed oil, are unobjectionable. Sometimes a combination of a hardwood floor in front of, and tiling or marble under, the fixtures may be used with success. Terrazzo floors are occasionally used, or plain asphalt or cement floors, but the latter are not quite so inviting in appearance.

The **walls** should preferably be rendered waterproof and protected against splashing by either marble or glazed tiling carried up to the height of the ordinary wainscoting. Cheaper means of protection are a smoothly polished cement or rock-plaster finish, which may be enamel-painted, or else the leather or sanitary washable wall papers.

Having a damp-proof floor and an open arrangement of the plumbing fixtures, which will readily disclose the slightest leak, it is not necessary, unless the ceiling underneath should be expensively decorated, painted or frescoed, to use the usual unsightly lead safes, or the safe waste or drip pipes required with these. They only complicate the arrangement of the plumbing work, without being of any real practical value.

In large city houses more than one bath room is provided, the second one being generally located near the nursery, or near the guest room; this should also have a door leading to it from the hall, to make it accessible from other parts of the house. Some modern mansions have a bath room for each bedchamber, and the total number sometimes runs up to from eight to twelve.

It is not necessary to consider the general planning and arrangement of bath rooms in detail, for this subject has been exhaustively discussed in the author's book "Sanitary Engineering of Buildings," which also contains illustrations of bath rooms, to which the readers are referred.

It is desirable, however, to consider the principal types of fixtures for modern bath rooms, and to discuss in detail the bath tub, the lavatory and the water-closet.

The Bath Tub.—As regards the **material** suitable **for bath tubs,** the choice is practically confined to three kinds, viz., tubs of enameled cast iron, tubs of tinned and planished copper, and those molded in one piece of solid earthenware. Bath tubs are made of different lengths and of slightly different shape and form.

Occasionally, bath rooms are fitted up with a bathing pool of larger size, made of blocks of marble, or of iron and lined with marble slabs, or with tiles laid in hydraulic cement. Such a basin or pool is usually sunk in the floor and made accessible by marble or stone steps leading down to it. The arrangement is convenient and luxurious, but it also proves to be rather expensive, as it requires a special construction of the floor.*

Among the cheapest bath tubs are those of wood, which become offensive as soon as the wood begins to rot, when leakage is also inevitable. Such wooden tubs are used nowadays only for some forms of medical baths. Zinc-lined tubs are not costly but do not last long. Tin-lined tubs are better and also less objectionable in appearance.

The enameled iron and the solid porcelain bath tubs are in every respect the cleanest, brightest and most attractive looking; they are highly glazed on the inside surface, and rendered thereby entirely non-absorbent, so that for a sanitary fixture nothing better or more desirable could be found. The all-porcelain tubs are quite expensive, and next in order as regards the price come the enameled iron tubs.

Cheaper than either of these are the tinned and planished copper bath tubs of from 18 to 24 ounces' weight of the metal. The lighter and less expensive copper tubs, of from 10 to 14 ounces' weight, are easily dented and knocked out of shape, and should not be used where durability is expected. What is commonly, in America, called a copper tub is really a wooden bath tub blocked out to the desired shape and lined on the inside with copper. In England and on the Continent bath tubs are often made entirely of strong copper metal, and stand on the floor without any wood enclosure.

* See Gerhard, Modern Baths and Bath Houses.

These more expensive copper tubs offer some advantages in so far as they can be fitted up without woodwork, being set on strong metal legs and made to stand entirely free on the floor of the bathroom. Quite recently the manufacture of such all-copper tubs was begun in this country, but owing to the limited demand for them it soon stopped, chiefly owing probably to the recent success of the American potteries in the manufacture of all-porcelain tubs and the equally successful manufacturing industry of porcelain-lined iron tubs.

Another kind of tub which was not expensive was the steel-clad tub, which combined some of the features of the cast-iron and of the copper-lined tubs, being a shell of iron or steel with an inside lining of copper. It was set on legs, and provided with a hardwood rim at the top of the tub; but it was soon displaced by the handsomer and more durable porcelain-enameled iron tub.

The **waste arrangements of the bath tub** require some consideration. The usual and cheapest method is to have an outlet with strainer at the foot end of the tub, which outlet is closed by a brass or rubber plug fastened to a plated safety chain. To provide for the safe removal of water in case the supply faucets are accidentally left open, an overflow pipe is arranged, at the foot end of and behind the tub, opening into the tub near its top, where the overflow is generally protected against obstruction by a strainer.

The objections to this ordinary method of fitting up bath tubs are: first, the outlet is too small and considerably obstructed by the strainer, and does not allow the waste pipe to run full bore when the bath is discharged, hence the trap and waste pipe are but imperfectly flushed; second, the overflow pipe seldom receives a flow of water and is not flushed, consequently slime and soapsuds remain attached to its sides, and are difficult to remove, as the overflow pipe is usually inaccessible and hidden from view; lastly, the plug-and-chain device is quite unsatisfactory and inconvenient, for the plug is frequently torn away from the chain, and much dirt and slime accumulate in the many links of the chain, which are difficult to clean and practically always remain befouled.

To obviate the latter defect, a dozen or more waste arrangements have been devised, which did away with the plug and chain, substituting for it a valve or waste cock. All of them, however,

retained the objectionable feature of the concealed overflow pipe or channel.

A very simple device has been in use for many years, especially in Boston and the Eastern States, which removes all of the above objections. This is the **standpipe overflow,** or standing waste, already mentioned when speaking of servants' bath tubs, and which consists of a brass tube of proper length, which is inserted into the waste outlet of the tub whenever it is desired to fill the latter, and which is removed if the tub is to be emptied (see Fig. 50). It may be hung up on neat hooks over the top of the tub. The removal and handling of the standpipe every time the bath is used, besides being troublesome, is the frequent occasion of marring or denting the copper by accidentally dropping the heavy brass tube into the tub. Moreover, a slight inconvenience is sometimes complained of, especially in the case of short or French tubs, namely, that the standpipe is in the way of the feet of the person using the bath tub. Years ago I suggested the easy remedy of placing the standpipe in a proper recess at the foot of the tub. The suggestion was taken up by manufacturers, and both copper and porcelain bath tubs are now to be had in the market fitted with a standpipe placed entirely out of the way in a recess. The standpipe may be raised or lowered to empty or fill the tub by means of several very ingenious, simple and easy-working mechanical movements.

The standpipe and strainer are combined, so that the whole can be lifted up, taken out and easily cleaned by the housemaid. It is not always necessary to do this, however, for the space between the recess and the standpipe is ample to allow of cleaning the sides of the tub by means of a cloth. This forms in many respects the best sanitary bath tub device of which I have knowledge, and answers the chief requirements of a perfect plumbing fixture.

The outlet of the bath tub should be made very large to effect a quick discharge, for a thorough scouring of the trap and waste pipe is thereby secured and the tub is practically acting as a flush tank.*

* Other writers on sanitary plumbing have called attention to the defective arrangement arising from a tub with too small outlet. I quote from the articles on "Plumbing Practice" in the *Sanitary Engineer*, Vol. 4, Dec. 1, 1880, page 12, the following: "There are one or two points in connection with the fitting up of baths that I wish to dwell upon. The first is the almost universal practice here in the United States of

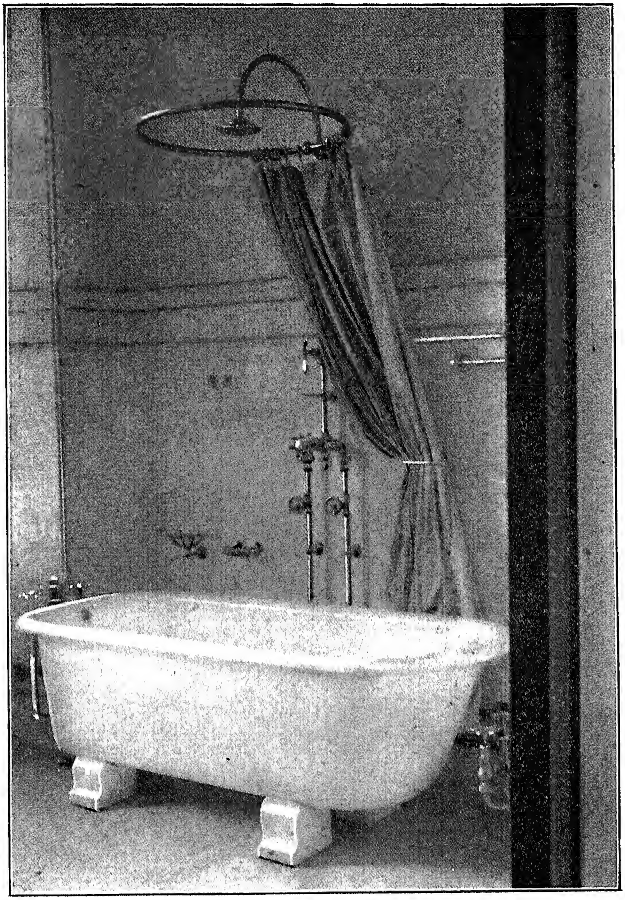

FIG. 55. View of Bath Tub with Shower.

Fig. 55 gives an illustration of a porcelain-lined iron **bath tub** equipped **with an overhead shower** arrangement. To prevent the splashing over of the water, a curtain holder with a plain cotton

employing too small waste plugs or outlets, one and one-fourth inch and one and one-half inch being the sizes most frequently used. It must be borne in mind that even these dimensions do not indicate the real internal capacity of the outlet, because the thickness of the metal and the gratings must be deducted from this size. In addition to the annoyance a bather is subjected to by having to wait for a bath to be emptied through such a small outlet, the waste pipe is deprived of the sanitary advantage of being decently flushed when a bath is emptied, and that it is an advantage can be readily appreciated when we realize the scouring effect produced by the rapid discharge of say fifty gallons of water."

duck or silk-lined rubber curtain is provided. This forms a thoroughly sanitary and conveniently arranged bathing appliance for those who prefer taking a bath in a tub.

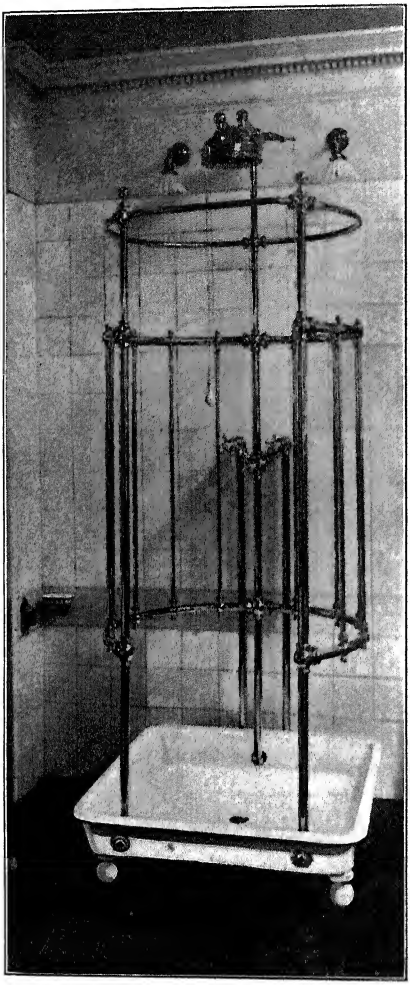

FIG. 56. View of Needle Bath.

Others much prefer to have in place of a bath tub with overhead shower a regular stall of marble fitted up with an overhead, generally inclined, douche or spray (the so-called **rain bath**). It should be mentioned that the same arrangement of an inclined douche can also be fitted up over the ordinary tub. This arrangement and the **rain bath** are illustrated in the writer's **book on Baths,** already named.

Some bath rooms are fitted up with a complete **shower and needle bath,** such as shown in Figs. 56 and 57. This fixture is made entirely of nickel-plated brass tubing, and stands in a porcelain or enameled iron receptor, generally three or three and one-half feet square, or made circular, and provided with strainer over the outlet and a waste pipe of large size to the soil pipe. Such shower and needle baths are made in a great variety of forms and at various prices.

The Bidet, Sitz and Foot Bath.—Another plumbing fixture which is often fitted up in modern bath rooms, and which is both useful and convenient, is the **bidet.** This is generally made in all earthenware, in pedestal form, and provided with flushing

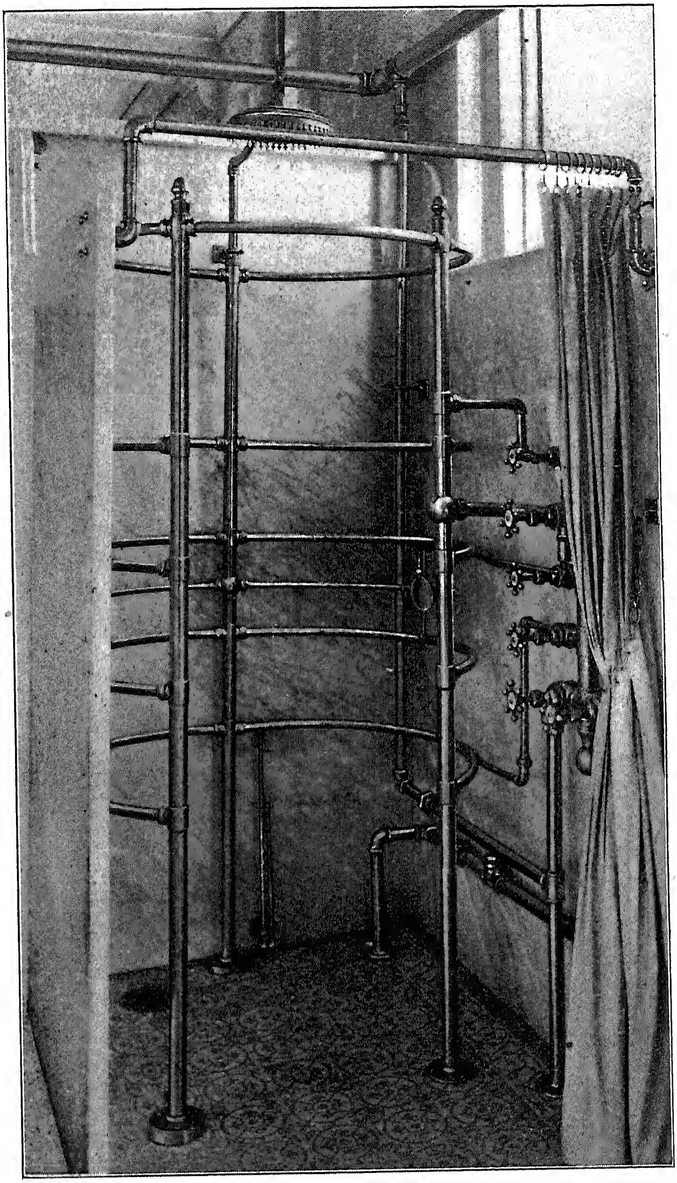

FIG. 57. View of Needle Bath.

rim and with waste and hot and cold water supply fittings. (See Fig. 58.)

FIG. 58. View of Bidet.

In place of a bidet, the bath room sometimes contains a **sitz bath** or else a foot tub, in addition to the regular bath tub. The manner of fitting up these fixtures does not differ materially from that recommended and described for bath tubs, hence separate illustrations of these fixtures are considered superfluous, and the reader is referred to some of the well-illustrated modern catalogues of manufacturers of sanitary specialties.

Bath-room Auxiliaries.—Figs. 59 and 60 show some modern bath-room auxiliaries which are fitted near the bath tub or over the lavatory—a plate-glass or porcelain shelf, with sponge and tumbler holders, a medicine closet and other appurtenances.

The Lavatory. — An important fixture of every bath room is the **wash basin, washstand or lavatory,** consisting of slab, bowl, supports, faucets, supply pipes and waste arrangements. Concerning the material for the bowl proper, there is not a great deal of choice. Wash basins are sometimes made of galvanized iron, or of tin or

copper, but the use of such cheaper fixtures is confined to the inexpensive plumbing in factories, restaurants, theater dressing

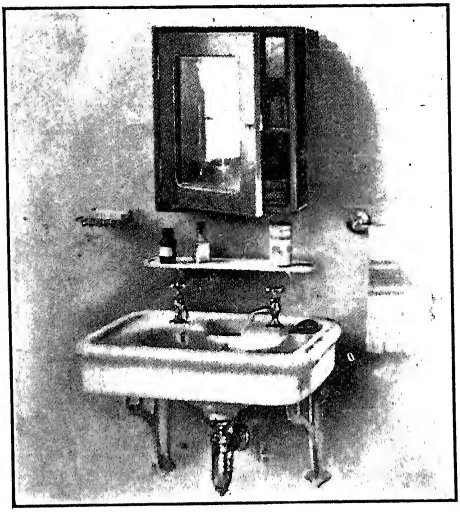

FIG. 59. A Group of Bath Room Auxiliaries.

rooms, etc. For private houses wash bowls of vitrified porcelain ware or of china, and those of solid stoneware, are much to be preferred.

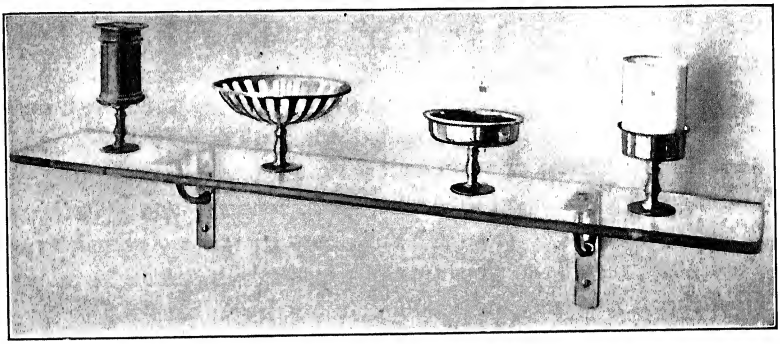

FIG. 60. View of Bath Room Auxiliaries.

Earthen wash bowls used to be made circular in shape, in diameters ranging from 10 to 20 inches, but now they are more often of an oval shape, for this seems to offer some advantages in actual use

over the circular form. Basins may also be had which are made square in shape.

The earthenware is plain white, marbleized, or ivory-tinted, and sometimes it is ornamented with fancy decorations. This, of course, is merely a matter of taste, but my experience is that many people select such expensively decorated and fancy-looking plumbing fixtures who are not willing to pay for the extra cost of a superior drain or soil pipe, or of a good trap or other plumbing fitting. In this respect the majority of the public have yet much to learn, and still more to unlearn. I should have no objection to the use of fancy articles in a house, provided I was not thereby curtailed from otherwise employing throughout the best sanitary appliances available. In my own judgment, plain white or ivory-tinted earthenware looks fully as neat, cleanly and chaste as any amount of colored or gilt decoration put on it, and it is certainly an indication of a more refined taste.

Earthen or porcelain wash basins are usually fastened with brass bolts and clamps to the underside of the marble slabs, the joint between both being made tight by means of plaster of Paris or Keene's cement. The slab may be of a square, rectangular, quarter-circle, or of a more irregular shape, and it is usually fitted with a marble back, more or less high, and either plain or with marble shelves supported by brackets. If placed in a recess or corner, the sides are fitted with one or two marble end-pieces, to protect the wall from splashing.

To the minds of most people the ordinary wash bowl, with outlet in the center, with strainer at the bottom, with overflow holes and a concealed overflow pipe at the side, and with a plug and chain, has no objectionable features whatever, and hence it has been and is still to a great extent in use. Yet, from a sanitary point of view, the ordinary wash bowl, as shown in Fig. 61, deserves to be severely condemned. In this connection I quote from Mr. J. Pickering Putnam's articles on "Sanitary Plumbing," published some years ago in the *American Architect* :

"The character of our lavatories is a matter of very much greater importance than is usually supposed. We have been in the habit of selecting our wash basins and bath tubs purely from a standpoint of convenience, appearance and economy. Sanitary considerations have

been quite overlooked in the belief that they have little or nothing to do with the form of these particular fixtures, so long as their traps and waste pipes were properly made. This is a very serious error, and particularly so in relation to wash basins, in the choice of which sanitary considerations should outweigh all others."

By far the most serious **defect of** our **ordinary wash bowls** is the insufficient size of the outlet in proportion to the size of the trap and waste pipe. The amount of waterway of an ordinary basin

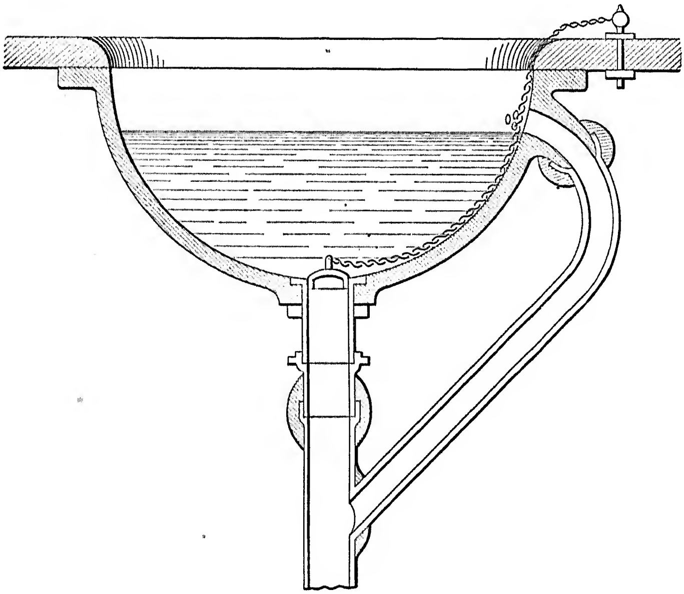

FIG. 61. Basin with Chain and Plug.

strainer, according to Mr. Putnam, is only equivalent to a three-fourths-inch pipe, and after some use this opening is apt to be still further obstructed by accumulations of filth, hair or lint. The usual size of waste pipe for basins is one and one-half inches inside diameter, which is ample to carry off all water, if both faucets are kept running a full stream into the bowl; but many architects still call for two-inch pipes and traps. The result of a restricted outlet is a trickling flow of water from the basin, which is wholly unable to accomplish any scouring or flushing of the large trap and waste channel.

A further **objectionable** feature of the ordinary plug-and-chain

outlet basin is the **concealed overflow pipe** of lead attached by an imperfect putty joint to the earthen projecting horn of the bowl. This overflow pipe is never flushed with water and its walls become coated with soapy slime, which decomposes. Since the overflow is in open communication with the room, the atmosphere of the latter is often contaminated to a noticeable degree. The basin with all-earthen overflow (so-called patent overflow basin) is better in this respect, yet it retains some of the objectionable features enumerated. The plug-and-chain arrangement of basins is also open to serious objections, both on the ground of convenience in use and of sanitation. To quote again from Mr. J. Pickering Putnam's articles:

> "The chain, lying in every successive formation of dirty water, collects gradually in the recesses of its links an unknown quantity and variety of filth, which cannot be entirely removed, on account of its irregular form, without the use of special acids or constant scrubbing with the brush — a process never applied to it. The length of wire used in an ordinary basin chain averages six feet, and has a surface of about fourteen square inches, a surface which, in the peculiar adaptability of the form of the links for retaining dirt, presents a very formidable area of pollution. To those persons who use their reasoning powers in these matters, the idea of washing the face in water defiled by a chain, transferred immediately from the dirty water of some unknown predecessor, is with good reason exceedingly repulsive. The chain, moreover, frequently breaks, and then the hand must be plunged into dirty water to remove the plug. The position of the chain and plug at the bottom of the bowl is, moreover, peculiarly inconvenient, inasmuch as they are in the way of the hands, which should meet a smooth, unbroken surface of earthenware, rather than the hard and irregular outline of the brass-work."

To avoid the annoyances incidental to the plug-and-chain arrangement, basins have been constructed with various more or less complicated forms of outlets, such as **waste-cock or valve outlets,** with plunger, floating plug or secret standpipe outlets (Fig. 62), but in all of these forms the overflow remains concealed and inaccessible, and a channel of more or less length remains in communication with the bowl, thus causing a soiling of the pure water as soon as it is delivered into the basin. Moreover, some of these movable mechanisms are quite apt to get out of order or to leak.

A form of basin which is quite popular in Europe, and which has occasionally been used in the United States, has the advantage of

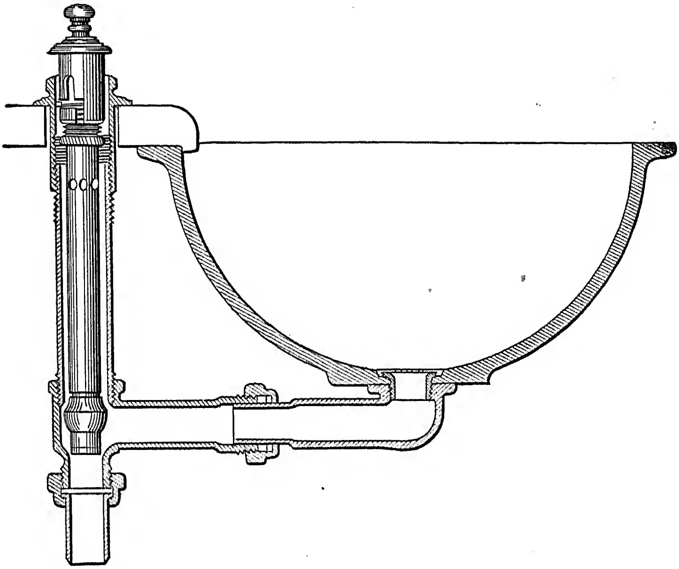

FIG. 62. Basin with Secret Waste.

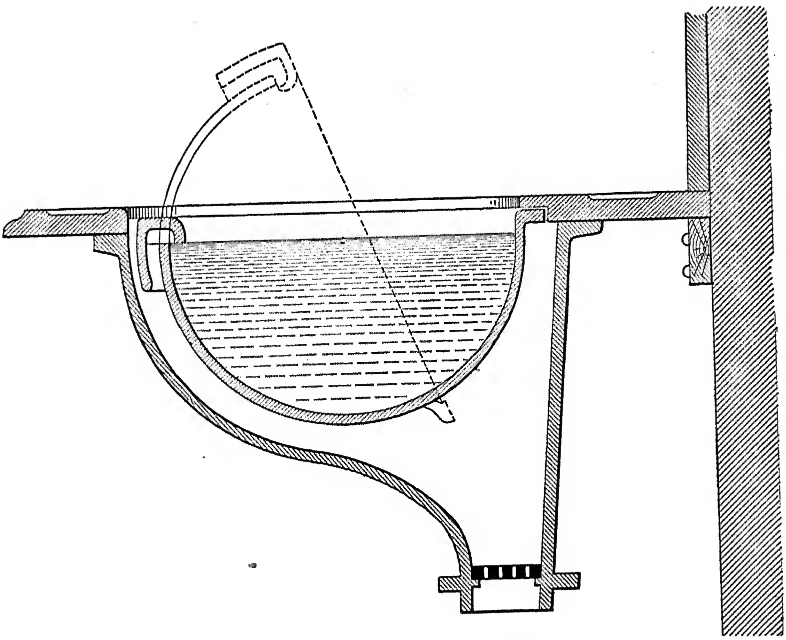

FIG. 63. Section of Tip-up Basin.

doing away with the objectionable overflow and also with the chain-and-plug arrangement. I refer to the **tip-up basin** as shown in section, in Fig. 63. It consists of an outer receiver or basin, usually in the shape of a hopper, and an inner bowl, pivoted so that it may be turned over by lifting it at its front edge. By means of this device a very quick discharge is obtained, and for this and other reasons it must be pronounced far superior to the ordinary form of bowl. It has, however, one defect. The lower basin or receiver, as usually constructed, is only partially accessible, and not being exposed to view is generally forgotten and seldom cleaned by servants. It is, therefore, liable to accumulate hidden foulness. A recent modification of the tip-up basin allows the inner bowl to be lifted from its pivots, and when the bowl is removed, the receiving basin is fully exposed to view and readily cleansed.

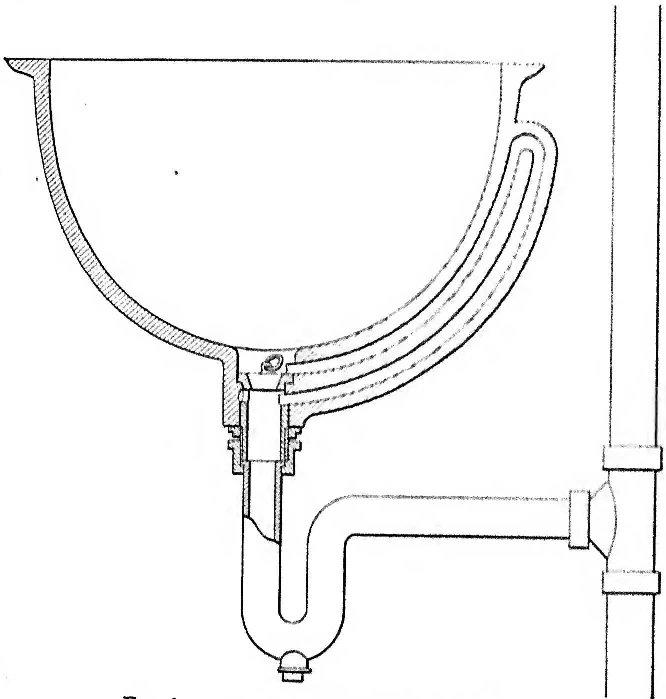

FIG. 64. Improved Form of Siphon Basin.

Fig. 64 shows a vertical section of an improved form of chain-and-plug wash basin. This is a **siphon basin,** so named because the over-

flow pipe is shaped in the form of a siphon. It will be seen from the illustration that in this type the overflow channel does not enter the bowl near its top, but at the bottom. This requires a special construction for the socket coupling of the basin. Such a form of bowl has two great advantages, namely: first, the overflow channel becomes trapped whenever the bowl is partly or entirely filled with water; second, whenever the plug is lifted to discharge the bowl a part of the contents will pass out by siphonic action through the overflow channel and thus flush the same, a feature of no other form of basin with overflow, with which I am acquainted.

Thus, every time the basin is used, the overflow becomes flushed and cleaned, and again, where such a basin is fitted up in a bedroom of a hotel, for instance, one is enabled to guard against entrance of sewer air by simply filling up the basin and keeping it full overnight. Owing to the assistance rendered by the siphon action of the overflow, the discharge of this form of basin is very much quicker than that of ordinary chain-and-plug basins, and this helps to keep the trap clean and free from obstructions. I have had a basin of this construction under personal observation for about twelve years, and during this period it has not once become stopped up, has never emitted an objectionable smell from the overflow, and empties to-day as rapidly as the day when it was put in.

Another method of constructing a basin without overflow is shown in Fig. 65. It represents an **oval basin** provided at the bottom **with** a quick-turning **gate valve** with full waterway. When this is closed the basin can be filled; a quick turn of the valve discharges the contents of the basin. No chain and plug and no overflow are provided. It would, however, hardly be safe to use such a form of wash basin in a private house or in a hotel. It can only be used to advantage in places where an accidental overflow does no harm, and it is particularly adapted to places and lavatories where a constant oversight is exercised

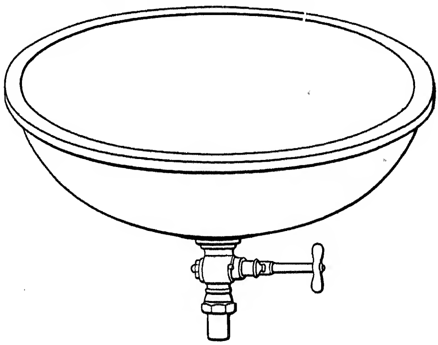

Fig. 65. Basin with Shutoff Waste Valve.

over the fittings, such as, for instance, in lavatories and toilet rooms of hospitals for insane, in which the patients' ablutions are always overlooked by attendants.

One of the best forms of basins of which I have knowledge is the **standpipe outlet type of basin,** the first form in which this was made being the well-known "Sanitas" wash basin, shown in plan and section in Figs. 66 and 67. This type of fixture is vastly superior, in my judgment, to all those complicated and insanitary devices which consist of secret waste valves. It has many superior features of simplicity, convenience and sanitary construction, I will therefore briefly describe it.

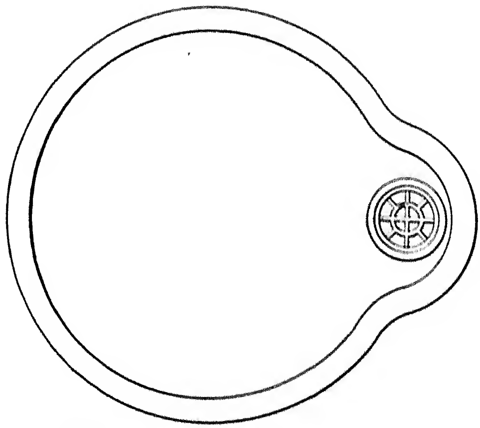

FIG. 66. Plan of Standpipe Basin.

The basin is made in earthen or vitreous ware, both in the usual round and in the oval form. Every part of the basin and of its fittings and passages is visible and kept easily accessible. It is entirely free from concealed chambers or easily befouled corners, and the basin is kept clean from top to bottom, even as far down as the waste pipe and trap, without removing the basin or any part of it. It is of the utmost simplicity, of great convenience in use, and of pleasing appearance. It differs from the usual basin in having its outlet at the rear, thus presenting a bottom of the bowl entirely un-

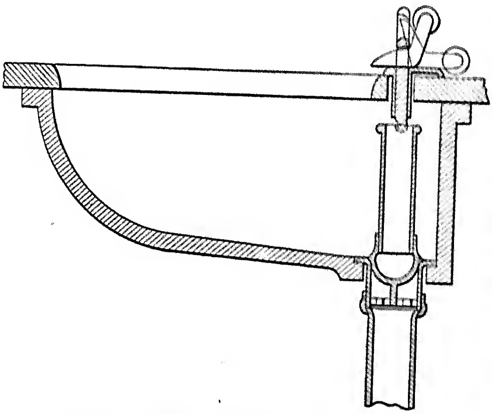

FIG. 67. Section of Standpipe Basin.

encumbered or roughened by any brass grating or socket and plug. The diameter of the brass outlet at the bottom of the basin is two inches, and, allowing for the obstruction caused by the strainer, it has a clear waterway of about one and one-half inches, equal to the size of the waste pipe attached to it, and hence a very rapid flushing discharge is secured. In fact, the rush of water from this basin through the waste pipe and trap is so great that the seal of even a ventilated S-trap may be destroyed by it. In order to restore the seal, the bottom of the basin has only a slight inclination toward the outlet, so that the last flow of water from it is sufficiently retarded to restore the seal of the trap.

It is thus seen how the great desideratum that the fixture should act as a flush tank for its waste pipe and trap is here accomplished. The basin is shaped with a perpendicular recess at the back, and in this recess, completely out of the way of the user, is placed the standpipe overflow — sometimes a nickel-plated tube one and one-quarter inches inside diameter and about four inches high, or else a porcelain tube — which serves to close the outlet of the basin if it is desired to fill the latter. This overflow pipe has a smooth surface, and enough space is provided between the standpipe and the walls of the recess to allow the convenient use of a scrubbing cloth, so that both the basin and the standpipe may be cleansed without the necessity of removing the latter. But the removal of the standpipe, should this be desired, is easily accomplished.

The standpipe outlet basin is superior to ordinary forms with overflow pipe in other minor respects, one of them being that it requires fewer joints for the plumber to make, and that it does not offer any temptation to unskillful and ignorant mechanics to connect the overflow pipe, as required in the ordinary form of bowl, to the wrong side of the trap attached to the waste pipe. In short, the standpipe type of wash basin offers the following advantages: It is a quick-emptying, self-cleansing, back-outlet basin, with concealed overflow. Through it waste water is completely and rapidly removed, a quick discharge, as from a small flush tank is effected, filling the pipes full bore, and the trap and waste pipe are thoroughly scoured. It provides for an overflow without requiring a special pipe or valve for this purpose; it has no brasswork in the bottom of the bowl in the way of the hands when washing, and no chain and plug. The wasteful habit

of washing in running water is rendered unnecessary, and hence it tends towards the prevention of water waste in dwellings, which is a matter of much importance. The whole of the fixture and all its parts and appendages are visible and readily accessible; its outlet is

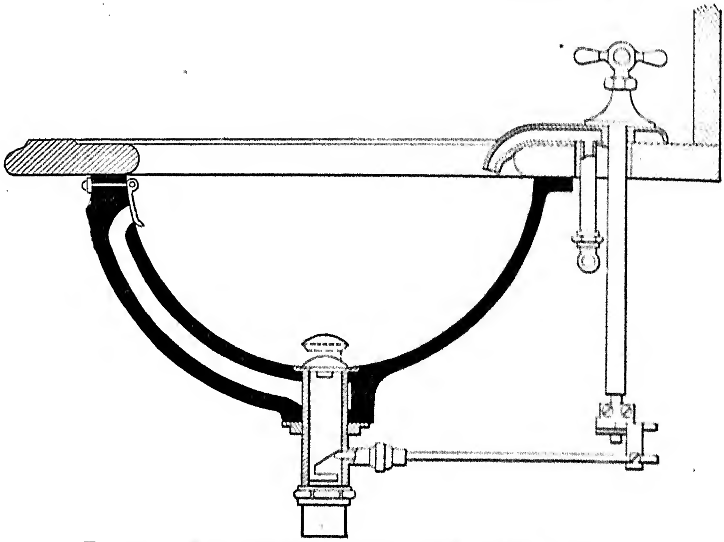

FIG. 68. Section of Basin with Lift-up Plug Arrangement.

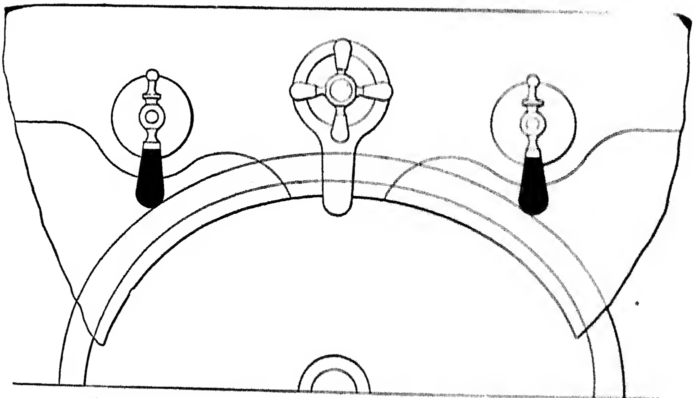

FIG. 69. Plan of Basin Shown in Section in Fig. 68.

controlled by a very simple single movement, which mechanism requires only very little strength to operate. It is easily attached to the slab, readily fitted up by the plumber, and has no concealed parts liable to clog or become obstructed. In short, it is a very durable, simple and well-constructed *sanitary* plumbing fixture.

A basin with a waste fitting arranged on a novel principle is shown in vertical section in Fig. 68 and in plan (half of the bowl only being shown) in Fig. 69. Briefly described, this basin has in place of the ordinary chain-and-plug arrangement a flat metal disc or stopper,

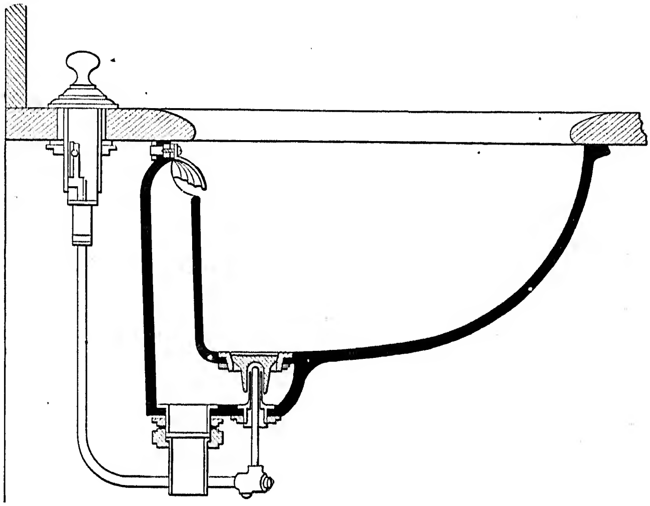

FIG. 70. Section of Different Form of Basin with Lift-up Plug.

which fits into the bottom outlet of the basin. This stopper is raised or lowered by means of an eccentric rod and cam movement. The eccentric rod is worked by means of a vertical spindle provided above the slab with a four-arm handle which is turned to the right or left to open or close the outlet. This form of basin retains the ordinary form of overflow, but it has the great advantage over styles of basins with secret waste valves of closing the basin outlet directly at the bottom and in full sight. Clean water filling the basin is therefore necessarily pure water, as it does not have an opportunity of coming into contact with the befouled sides of secret waste channels. The overflow is also made larger and somewhat more accessible for cleaning.

Incidentally mention should be made of the convenient method of supply to the basin by means of a combination faucet surrounding the spindle of the waste fitting, the water (hot and cold) being controlled by two handles placed at the side of the cross handle operating the waste.

A basin with a similar waste arrangement is shown in Fig. 70, but

instead of being operated by means of an eccentric and a cross handle turning horizontally, the metal stopper is lifted or dropped by means of a vertically operating lifting spindle with knob above the

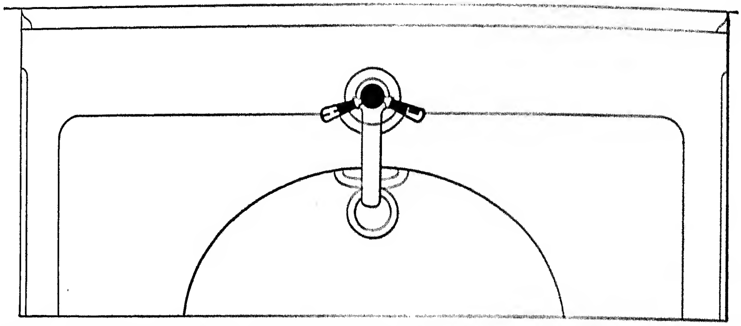

FIG. 71. Plan of Different Form of Lift-up Plug Basin with Supply and Waste Combination.

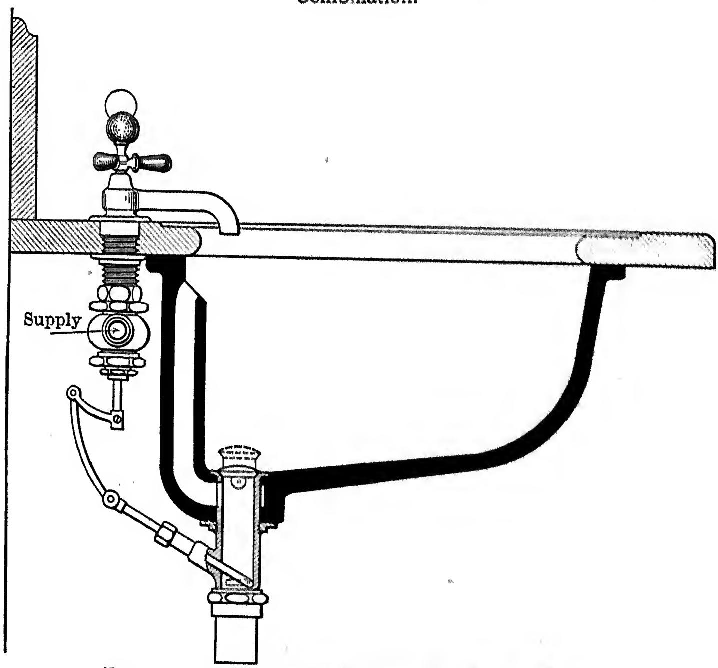

FIG. 72. Section of Basin Shown in Plan in Fig. 71.

basin slab. In all other respects this basin has the same advantages as those mentioned for Fig. 68. Still another basin of this type, with a novel form of supply fitting, is shown in plan and section in Figs. 71 and 72.

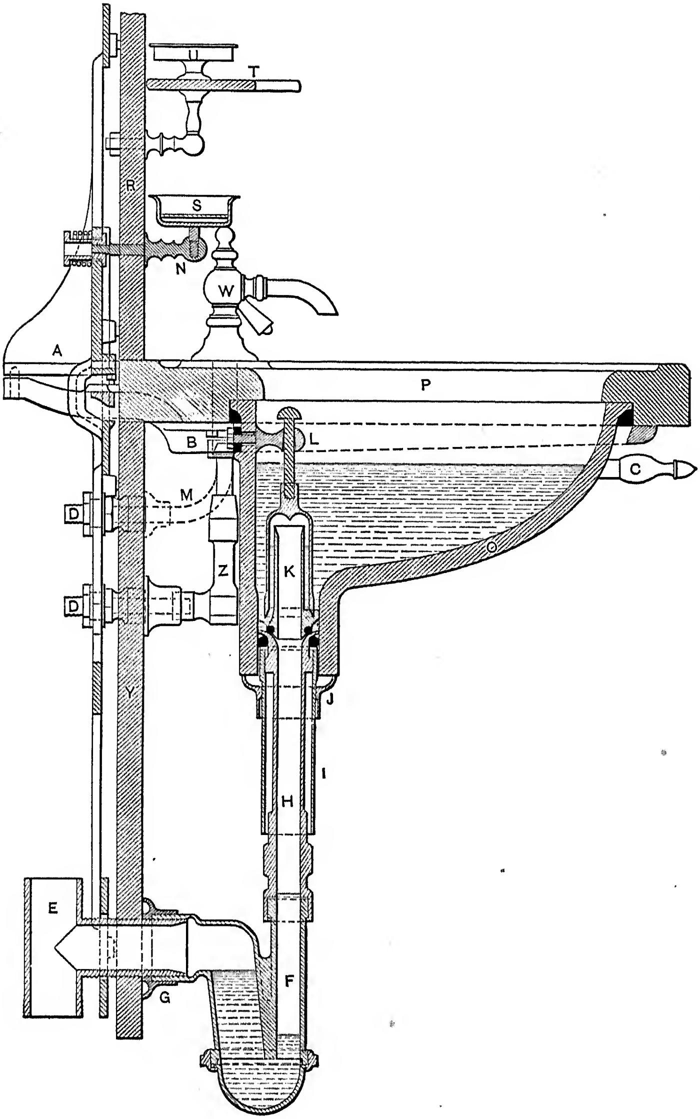

FIG. 73. Section of Riker Basin.

The distinguishing feature of the basin shown in section in Fig. 73, which is designated from the name of its inventor as the **Riker basin,** is that only one passageway is provided for both the waste and the overflow. In this respect it resembles the standpipe basin, Fig. 67. The bowl is molded with a pitch to the back, and has in place of a plug a standpipe siphon *K*, and the water is held in the basin, when the same is being filled to the overflow point, by the confined column of air held between the siphon and the trap. If more water is allowed to run into the basin, it overflows through siphon *K*, and induces a siphonic action by means of which the entire basin is emptied and thus it can never overflow. To empty a full bowl, the siphon *K* is lifted for a second at knob *L*, and then allowed to settle again into its seat; this starts the discharge of the basin, which continues automatically and thoroughly cleanses the waste and overflow passages. A trifling objection is that the last water siphoned up drops back into the bottom of the bowl.

A feature of great importance in this basin is the special brass trap, which is reamed absolutely smooth on its inside by means of special machinery. Thus all broken or ragged joints and pockets for the accumulation of filth are avoided.

The inventor of this wash basin made further improvements, principally in the manner of fitting up the lavatory. Special iron wall plates are furnished to which all parts of the slab are attached which can be set in place when the roughing of the fixture is done, when waste and supply connections are also made, thus permitting the finishing of the walls, and the lavatory proper can be attached to said wall plate at any time afterwards.

A point of value is the doing away with the ordinary unsightly plaster-of-Paris joint and the securing of the basin to the marble slab by means of the usual basin clamps. In the Riker basin system, the marble slab is made very thick and is rabbeted underneath to receive the bowl, which is cemented thereto securely as shown in the section, thus making a smooth exterior finish.

All lavatory auxiliaries such as towel racks, soap cups, glass shelves, swivel mirrors, tumbler holders, etc., are attached to the wall plate. A view of a complete Riker lavatory is shown in Fig. 74.

Instead of having the usual more or less expensive cabinet work enclosing the space under the bowl, which space is always rendered

damp, musty or even foul, the basin should be kept entirely open and accessible underneath. Cleanliness and tidiness will thus be much promoted, and the mechanics, knowing that all of their work will remain fully exposed to view, will have no temptation to scamp those parts of it which are usually buried out of sight and out of mind as soon as made.

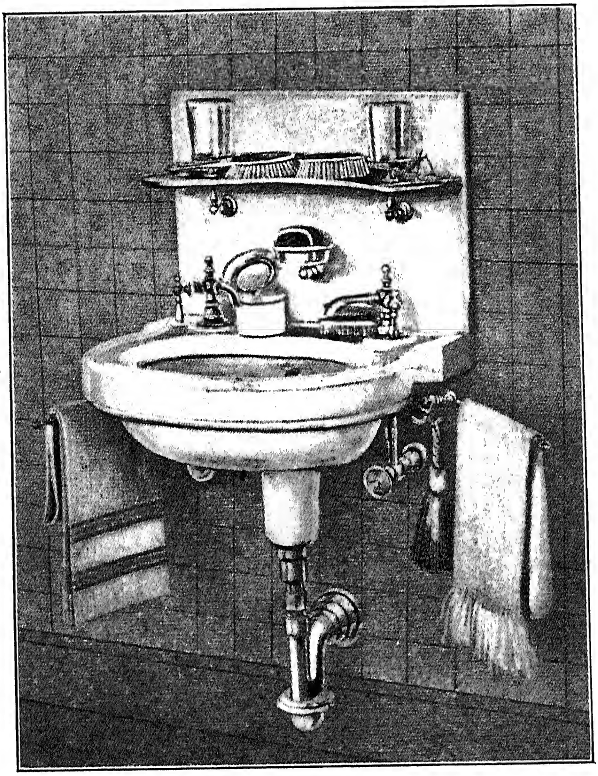

FIG. 74. View of Riker Basin.

In Figs. 75, 76, and 77 are shown illustrations of **modern lavatories** fitted up entirely in an open manner.

A large variety of more or less artistically designed solid porcelain lavatories are now offered by manufacturers, and a visit to one of their well-equipped showrooms, or a study and inspection of their well-illustrated catalogues, will convince any one that these are sanitary fixtures well adapted not only for public and office buildings, for hospitals, institutions and hotels, but also for private residences.

FIG. 75. View of Modern Lavatory.

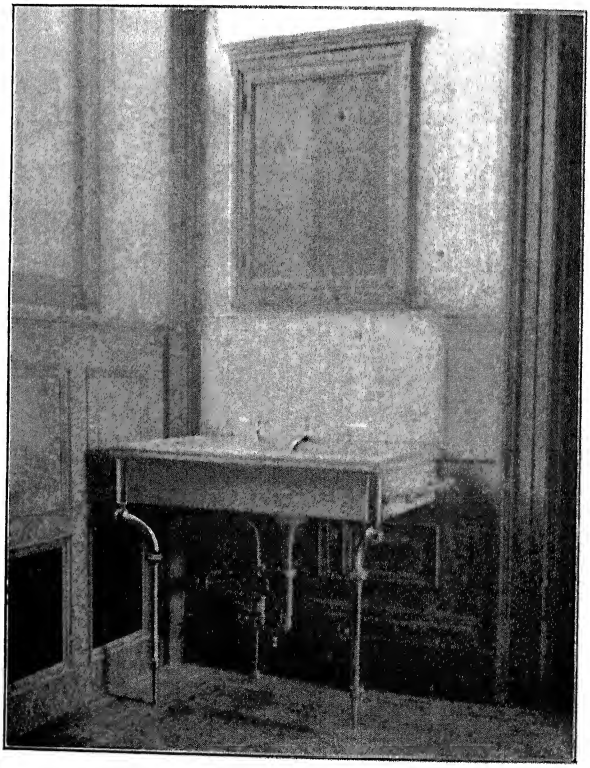

FIG. 76. View of a Lavatory.

The chief advantages which solid porcelain lavatories offer, compared with marble washstands, are:

1. Their highly glazed surfaces are non-absorbent and do not become discolored or stained.

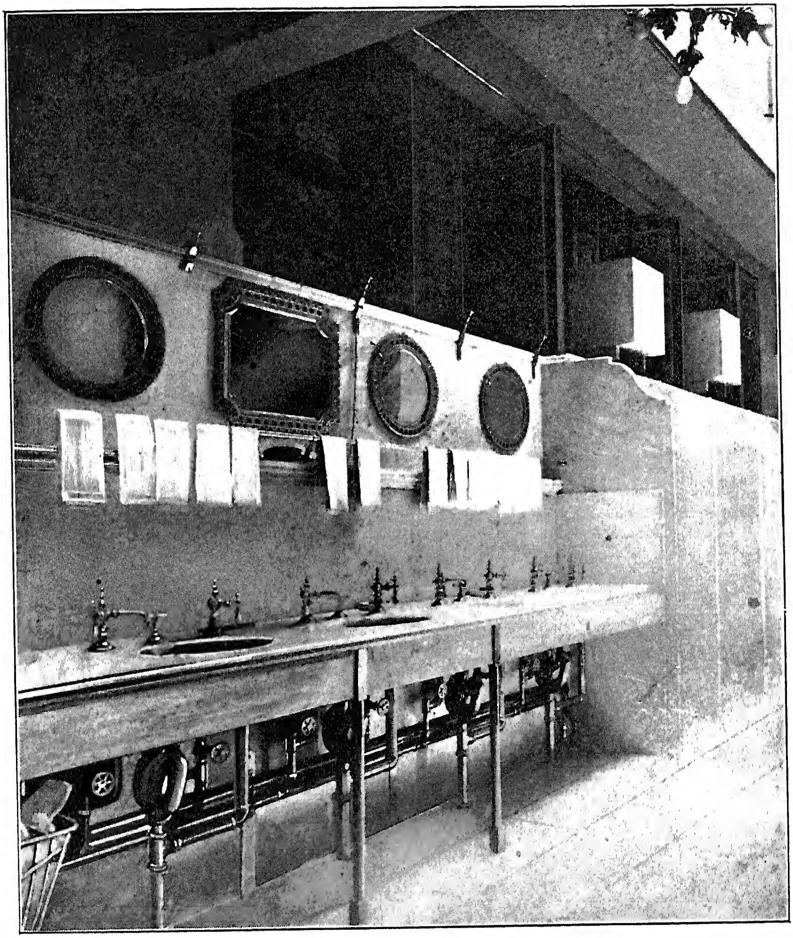

FIG. 77. View of a Group of Basins.

2. The objectionable plaster-of-Paris joint between earthen bowl and marble slab is done away with, the lavatory, basin and slab being all in one piece.

3. To the plumber there is an advantage in the saving of time and labor in fitting up a washstand.

4. To the architect and building superintendent there is the advantage in doing away with the trouble of obtaining a high quality of marble without any dark streaks, veins or other imperfections.

5. Other slight advantages are the doing away with aprons for lavatories; the large size of the basin; and the general cleanly and inviting appearance.

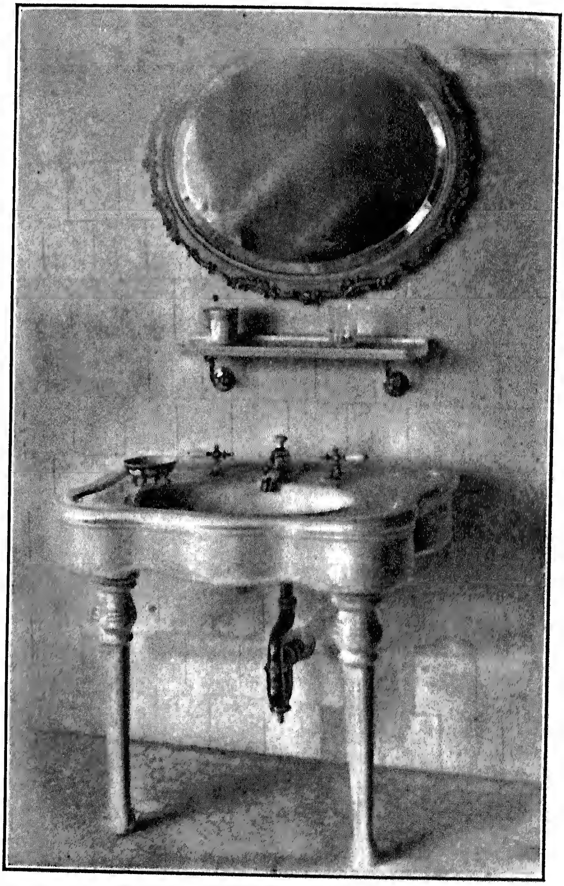

FIG. 78. View of Solid Porcelain Lavatory.

6. Solid porcelain lavatories are also more durable and strong.

7. The glazed porcelain supports save the time required in the cleaning of nickel-plated brass basin legs or standards.

The **white solid porcelain lavatories** (Fig. 78) made by the best firms are neat in design and appearance, generally of a pleasing shape,

of a beautiful glaze, and taken altogether are a sanitary fixture which cannot be improved upon. They may be either keyed into the tiled walls, or else they stand free from the wall, with all four side edges glazed and rounded. Lavatories with integral backs have an advantage over those with separate backs in doing away with another undesirable plaster-of-Paris joint.

Simultaneously with the advent of the solid porcelain lavatories other makers brought out handsome, cleanly and sanitary **lavatories** made **of enameled porcelain ironware.** Of the durability and usefulness of these there can be no question. In appearance they are so nearly equal to the solid porcelain lavatories that many times householders selecting plumbing fixtures for their bath rooms have been led to believe the enameled iron fixtures were of the other somewhat more expensive material.

The Water-closet. — The water-closet fixture is usually placed in the bath room, or toilet room, but often, and preferably so, it is fitted up in a separate compartment or room. In many respects the **water-closet** is the most important plumbing fixture of a house. While it may be of doubtful advantage to have a water-closet in cottages not liberally supplied with water, especially when every drop of water must be raised to a tank by hand labor, there can be, on the other hand, no question that in the case of country residences having an abundant supply of water under pressure a water-closet proves far superior to earth or ash closets. As to city buildings, these are never complete without one or several such fixtures. A water-closet is in all respects the most complete apparatus devised for the instant and thorough removal of waste discharges from the human body.

In the selection of this fixture, however, more than anywhere else, a safe, reliable and impartial guide is required, for the number of various water-closet appliances manufactured is exceedingly large, and laymen will thus encounter considerable difficulty in making a proper selection.

The **leading requirements of a sanitary water-closet** are the following:

(1) Its material should be strong and durable, smooth and non-corrosive, and, above all, non-absorbent.

(2) Its form should be such as to have a minimum of fouling surface; it should have no sharp angles, but, on the contrary, rounded

corners; its sides should be nearly straight; its trap should preferably be above the floor, so as to have the water seal plainly exposed to view; its basin should be so shaped as to hold water, because this helps in immediately deodorizing the deposits, and prevents them from adhering to the sides of the bowl.

(3) Its appearance should be neat and inoffensive and its form and shape such as not to require any superfluous, costly and objectionable cabinet woodwork.

(4) Its construction should be simple and not liable to derangement; all unnecessary appendages should be avoided, and it is well, in particular, to have no movable machinery in the closet, such as tilting pans, hinged flap valves, gate valves, plungers, rods and chains, levers and cranks, or other parts.

(5) The flushing of the water-closet should be thorough, powerful, and such as to cleanse efficiently every part of the apparatus including its trap, but at the same time the flush should be arranged in such a manner as to be noiseless in operation and not wasteful of water. The flushing water should preferably be drawn from an elevated special tank or cistern, and not directly from the supply pipe.

The requirements enumerated above are not fulfilled by any of the older types, the so-called **mechanical** closets — that is, those which use some movable machinery in the closet apparatus to discharge the contents of the bowl. Hence the pan closet, the valve closet and the plunger closet cannot be recommended for use in buildings which are to be provided with good sanitary drainage. The chief objection to their use, aside from their complication and liability to derangement, lies in the fact that they do not effect a complete removal of the fæcal matter. The pan closet, once so popular with architects, plumbers and builders, was particularly faulty in this respect, as any one could easily ascertain by taking the trouble to investigate the inside walls of the container or receiver, which, after a few months' use, were invariably found coated and fouled, giving rise to a dangerous and annoying decomposition of fæcal matter within the house walls.

Having elsewhere* discussed the faults of the older types of

* See "House Drainage and Sanitary Plumbing," 13th edition, D. Van Nostrand Co., 1909.

closets at length, and seeing absolutely no reason for changing my views in the matter, I may be permitted to dismiss the subject with these few words.*

In the following I desire to speak more in detail of the modern simpler sanitary water-closet appliances. To such belong, more or less, all the varieties known as hopper closets, wash-out closets, wash-down closets, siphon and siphon jet closets. The distinctive feature in all of them is the absence of mechanical seals and of working mechanisms in the closet proper. In all these types the discharge of the contents of the closet bowl is effected by a sudden and powerful flush, usually from a special flushing cistern.

We may subdivide this class of closets further by distinguishing between hoppers having no standing water in the bowl outside of what water is contained in the trap, and hoppers the bowl of which is so shaped as to hold a more or less large volume of water. The former may be called **dry hoppers** to distinguish them from the latter, which are called **improved** or **pedestal hopper closets.** All pedestal closets have the trap above the floor, while the *long* hopper is a similarly shaped conical vase having its trap below the floor. The short hopper is, on the whole, preferable, because it has less fouling surface, and because the water level in the trap is nearer to the seat. All dry hoppers, both the long and the short, lack the advantage of a large surface of water in the bowl to receive deposited matters, and hence due care must be taken to shape the bowl in such a way that the sides may not be soiled. Much depends upon the character of the flush, and this, to be effective, should come down in a sudden dash through a large service pipe; it should enter the bowl at the top, and be thoroughly distributed and directed downward through a well-constructed flushing-rim. Dry hoppers with a spiral whirling flush should never be used, as it is difficult to keep their sides free from matter adhering to them. It is well to apply to all dry hoppers a "preliminary" flush sufficient to wet the sides of the bowl before use, and this, in the case of a servants' closet, is best arranged to work automatically by a mechanism

* At the present time pan-closets are scarcely to be found, except in very old houses. In many cities and towns the plumbing regulations very properly prohibit their use altogether. Valve and plunger closets have likewise been discarded, and replaced by wash-out, wash-down and siphon jet closets.

coming into action when the seat is depressed. (See Chapter V for description of a combination pull and automatic tank.)

Due regard should also be had to the **proper adjustment and construction of the seat;** a proper size and position of the hole in the seat will aid much in preventing the striking of the soil on the rear side of the hopper. With these precautions the dry hopper may answer the purpose where a cheap closet, free from hidden or inaccessible fouling spaces, is desired. It is obvious, however, that, to keep it thoroughly clean, requires more water than the improved hoppers, which hold a large volume of water in the bowl. Still I do not hesitate to pronounce a dry hopper, even if occasionally soiled from use, far superior to the pan, valve or plunger closet. With proper attention to domestic cleanliness, it is easy to keep even an ill-flushed dry hopper closet free from offense by a daily scrubbing with soap and hot water, while with mechanical closets the soiling of inside corners and surfaces may go on for a long time *unperceived*, and hence no effort will be made to remedy the trouble.

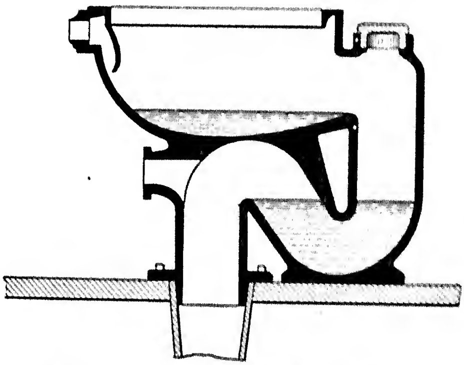

FIG. 79. Section of Wash-out Closet.

Amongst improved closets, which were used for a time in much of the better class of work, may be mentioned the **wash-out closet.** This type of closet (see Fig. 79) is made in one piece of earthenware, and shaped so as to hold a shallow depth of water in the basin to receive and deodorize the excrements, and a sufficient volume of water in the trap below. The flush is derived from a special cistern, and enters the bowl at a point directly opposite the closet outlet, or else at the same end where the outlet is situated. This may be located

either at the rear, at the sides, or in front of the closet, and it is easy to distinguish thereby the closets of various makers. They are usually known as the front-outlet, the back-outlet and the side-outlet wash-out closet. All these have flushing-rim bowls, and a generally powerful and cleansing flushing stream, which drives everything out of the basin into the closet trap. Here, however, more or less water remains, as the force of the flush is to a great extent lost in sweeping the basin.

Some of these closets have a bad spattering flushing; in others the traps are either not conveniently accessible or entirely out of sight. The majority of wash-out closets have at the outlet, between the basin and the trap, a rather large and easily befouled surface, which is superfluous and objectionable. All wash-out closets require a large volume of water, and have, as usually arranged, the same drawback which pertains to the dry hoppers, of a rather inconvenient and disagreeable noisiness when being flushed. Yet, notwithstanding all these defects, they were rightly considered vastly superior to the pan, valve or plunger type of closet, and for a long time they were much in use, until the manufacturers brought out other improved types.

Far better than the wash-out closets are those having the whole bowl so shaped as to form at once a trap against gases from the soil pipe. Such closets are sometimes called **"wash-down" closets** (Fig. 80), when the flushing stream is driving everything out merely by the downward force of the pelting water.

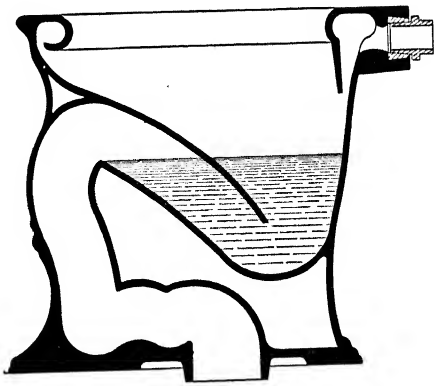

FIG. 80. Section of Wash-down Closet.

Closets of similar design, in which, however, a jet action serves to cleanse the trap and to remove the contents of the basin, are called **"siphon jet" closets.** In their earlier forms they were made in two pieces, the bowl being of earthenware and the body of the closet of cast iron (see Fig. 81), but later on they were molded in one piece of earthenware (see Figs. 83, 84, 85, 88).

To work properly, closets of this type require a flushing cistern placed at least six or seven feet above the bowl, hence they are not so well adapted to places having low ceilings. They also consume a

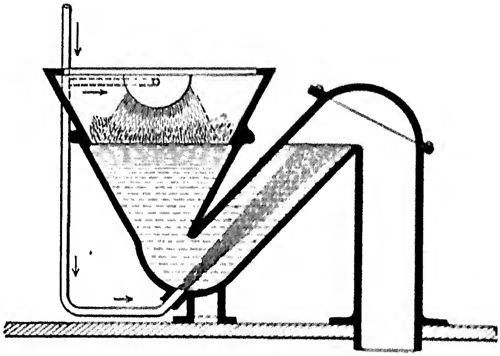

FIG. 81. Section of Siphon-jet Closet.

large quantity of water, viz., from four to five gallons at each flush, which fact may become a serious objection to their use in some places where the water supply is limited.

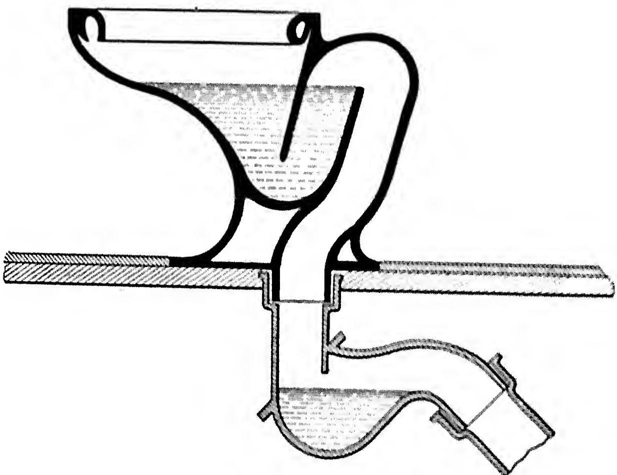

FIG. 82. Section of Siphon Closet.

An ingenious and in many respects excellent form of improved pedestal closet is the "Dececo" **siphon closet** (Fig. 82), which was the invention of the late Col. George E. Waring, Jr. It is made in one single piece of white earthenware, of graceful form, and the bowl is so shaped that it forms a deep water-seal trap, but the depth

is confined to the rear part of the closet, just where the water is most required. At the front the bowl is covered by only a shallow depth of water. In its early form the closet required a weir under the floor to aid in starting the siphonage. I quote the following from the inventor's description of the construction and operation of the closet:

> "In this closet I have tried to overcome the objections to the mechanical or valve closets, while retaining the very great advantage of a deep bowlful of water for the reception of deposits and for the suppression of odor. The closet has a seal 4 inches deep, a depth of water in the bowl of nearly 7 inches, disposed in the most useful way, and a sufficient submersion of the front part of the bowl. It has the advantage, also, that its seal is in full view, and always under control. When it seems to be right, it is right.
>
> "The closet is supplied with water through an ordinary flushing-rim, connected with a service box or cistern overhead, which is operated by a pull. When the latter is drawn, a capacious supply of water flows into all parts of the bowl through the flushing-rim, washing it completely and raising its water level rapidly. There is soon established a strong siphon action, which continues until the water in the bowl, into which a strong stream continues to flow, descends below the top of the intaking limb. Then air is admitted at this point and the flow through the siphon is checked. The water in the outgoing limb of the siphon falls back and establishes a water seal in the bowl. The service box is so arranged that after the main supply is stopped a small stream continues to be discharged into the bowl, until it is filled to the height of the overflow point."
>
> "The closet uses at each operation about 3 gallons of water, which gives a thorough flushing to the soil pipe and to the drain, while it has a further advantage of sending a good part of its water into the soil pipe in advance of the foul matter, thus lubricating their passage through the whole drainage system. Although this considerable volume of water is essential to its complete efficiency, the closet can be emptied by pouring a pailful of water into the bowl, an advantage which renders the closet equally adapted as a slop-hopper."

I have made use of this type of closet, which was later on modified so as to have no weir under the floor, in a great many first-class residences and in hotels, and the flushing of the bowl has been uniformly good, though the valve in the flushing cistern has at times given cause for complaint, a matter, however, not beyond remedy, and which has no reference to the excellent principle of the closet.

Another form of **improved pedestal closet** requires a somewhat detailed description, because it is of superior construction and its design based upon sound sanitary principles. This is the **Sanitas self-sealing water-closet,** shown in section in Fig. 83.

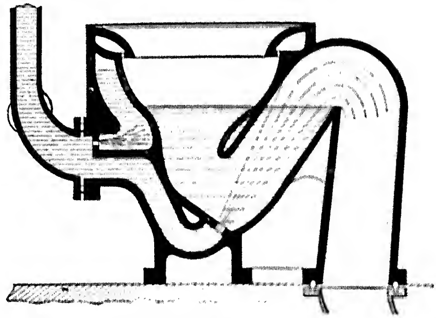

FIG. 83. Section of Sanitas Self-sealing Water-closet.

The closet is manufactured in white earthenware and resembles somewhat in shape the short hopper, having a bowl and a trap combined in one piece and no superfluous interior surfaces, angles or corners to which soil may adhere. The area of the bottom of the bowl is so shaped as to present a large surface of standing water to receive and deodorize waste matters, and the overflow point is raised much higher than usual in order to retain a deep body of water, and hence a deep water seal, in the bowl. It should be noted that the water is deepest at the rear of the closet, at the point where soil would be most liable to strike the sides.

The top of the bowl is provided with a flushing-rim into which the flushing water enters in a novel manner. To avoid the usually noisy operation of the flush and also the frequent spattering, the flushing water is conducted into a large body of water below the normal water level, from where it overflows into the flushing-rim and hence down the sides of the bowl.

Another part of the flushing water is directed, independently of the stream which feeds the flushing-rim, to the bottom of the bowl, where it enters through a jet or nozzle arrangement, discharging with great force into the ascending leg of the closet trap. This removes part of the water from the trap and causes that which is in the bowl to sink into its neck, where it is more easily acted upon by the upper flush. Meanwhile the upper jet fills the passage leading to the flushing-rim and, overflowing, descends upon and drives out the waste matters which have descended into the neck. The lower jet is always covered by water from the upper flush, the construction and proportions being such as to ensure this result. Hence both jets are noiseless.

In other trap-jet closets no provision is made to ensure the covering of the jets and a loud roar is occasioned. These closets, moreover, are emptied by siphonic action produced intentionally in the trap, and this emptying by siphonage adds to the jet roar a disagreeable "gulping" sound, caused by the sudden inrush of air under the dips as the water escapes. Both of these causes of noise are avoided by the flushing principle of the "Sanitas" closet, in which a trap vent nozzle is provided for the purpose of preventing the formation of a siphon by the supply of air. When entire noiselessness is not needed and the law does not demand universal trap venting this vent need not be connected.

The action of the "Sanitas" closet is almost instantaneous, it being possible to flush it easily in one second and with less than a gallon and a half of water.

Another peculiar feature of the flushing of this closet is the "Sanitas" water-closet supply pipe, in which all delay and noise occasioned by the water passing from the cistern down the service pipe, when the pull is operated and the cistern valve is lifted, are avoided by constructing the supply pipe on the principle of an inverted bottle, so that the water shall be hung in it below the cistern valve, as far down as the standing water in the bowl, simply by the pressure of the atmosphere. This supply pipe is, therefore, always full of water, the pipe being closed at the top by a cistern valve and at the bottom sealed by the water in the closet bowl. The flush is thus made to act instantaneously. The closet is self-sealing, for the moment the water in the trap is lowered to a certain point just above the dip of the trap, water follows from the upright supply pipe until the trap is refilled up to the overflow line. There is thus provision made for reëstablishing a perfect deep water seal if the latter should be lost by evaporation or even by siphonage. The latter case will but rarely occur, as the trap has more than the ordinary depth of seal. Evaporation, on the contrary, is constantly going on in houses closed during the summer months, and it is here where the advantage of the self-sealing closet and the "Sanitas" water-closet supply becomes most apparent. Finally, as every part of the closet bowl and trap is readily accessible and at all times open to inspection, it is easy to remove, by a sponge or otherwise, all water from the closet in houses to be left unoccupied during the winter, in which plumbing work is most exposed to freezing.

Shortly after the principle of the siphon-jet closets became known, several manufacturers of sanitary specialties introduced improved forms of siphon-jet and siphon water-closets, of which I will mention and illustrate several of the best types.

Fig. 84 is a vertical section through Mott's "Primo" siphon-jet water-closet apparatus. As the section shows, the bowl holds a

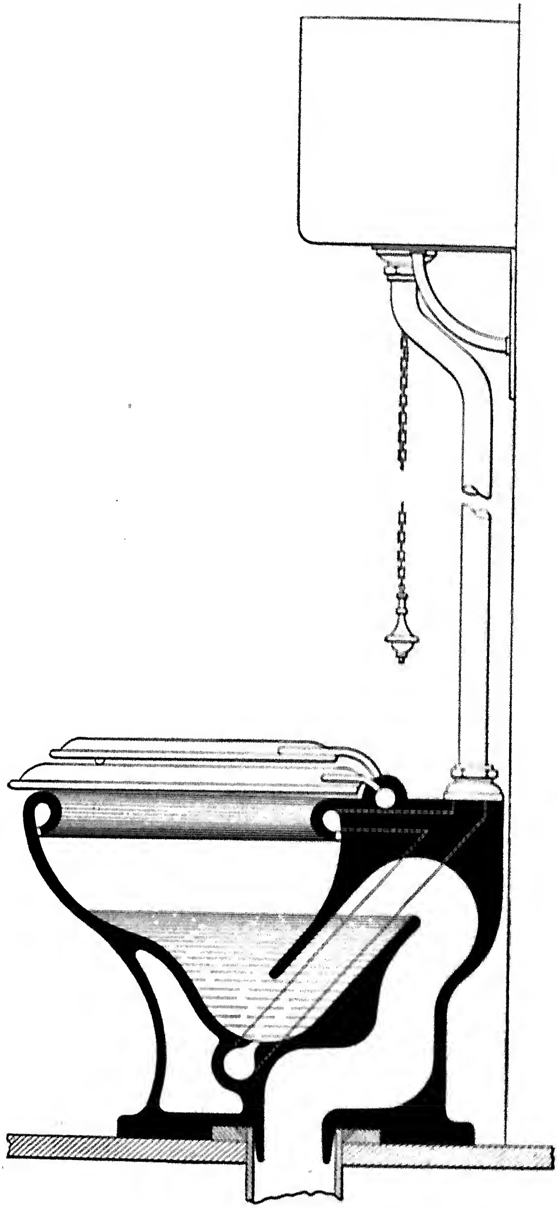

FIG. 84. Section of Mott's "Primo" Siphon-jet Water-closet.

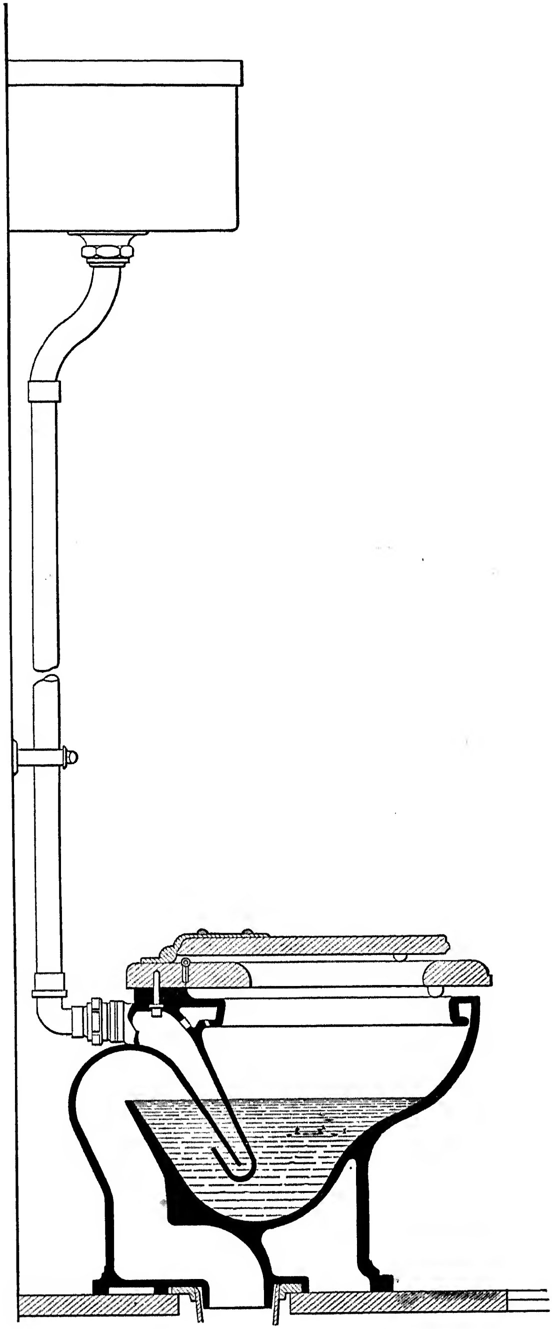

FIG. 85. Section of Improved "Primo" Water-closet.

large volume of water, and the bowl is judiciously shaped. The flushing water, coming from the overhead flushing tank, is divided at the entrance to the bowl into two streams, one of which enters the flushing-rim to wash the upper portion of the bowl, while the other stream descends to a lower jet, which assists in ejecting the contents of the bowl. A recent improvement of this closet consists in placing the orifice of the jet so as to be concealed, leaving the lower bottom of the bowl entirely free from holes in the earthenware or from brass jet pieces as used in some of the earlier forms (Fig. 85).

In Fig. 86 is shown an improved form of **floor connection** used in some of the closets made by the J. L. Mott Iron Works, and

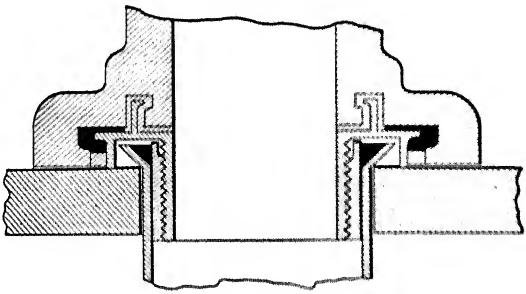

Fig. 86. Section of Mott's Improved Form of Floor Connection.

which is intended to give greater guarantee against leaky floor joints. A brass flange threaded on the outside is securely and rigidly cemented into the foot of the closet, and the lead bend is provided with a brass collar threaded on the outside. In setting the closet, it is screwed upon the brass collar soldered to the lead bend, and plumbago grease is put on the threads, as red or white lead would harden so much in the joint that the closet could not be unscrewed after once being set.

Fig. 87 shows the "Vortex" special water-closet manufactured by the Meyer-Sniffen Company. In principle it is similar to the siphon-jet closets previously mentioned and illustrated. It has a very good form of bowl and an efficient flush. The top of the closet and the flushing-rim are molded with a roll-rim which gives to the closet an excellent appearance.

Fig. 88 illustrates in section the form of the bowl of the "Pluvic" water-closet, another excellent closet of recent date, made by the

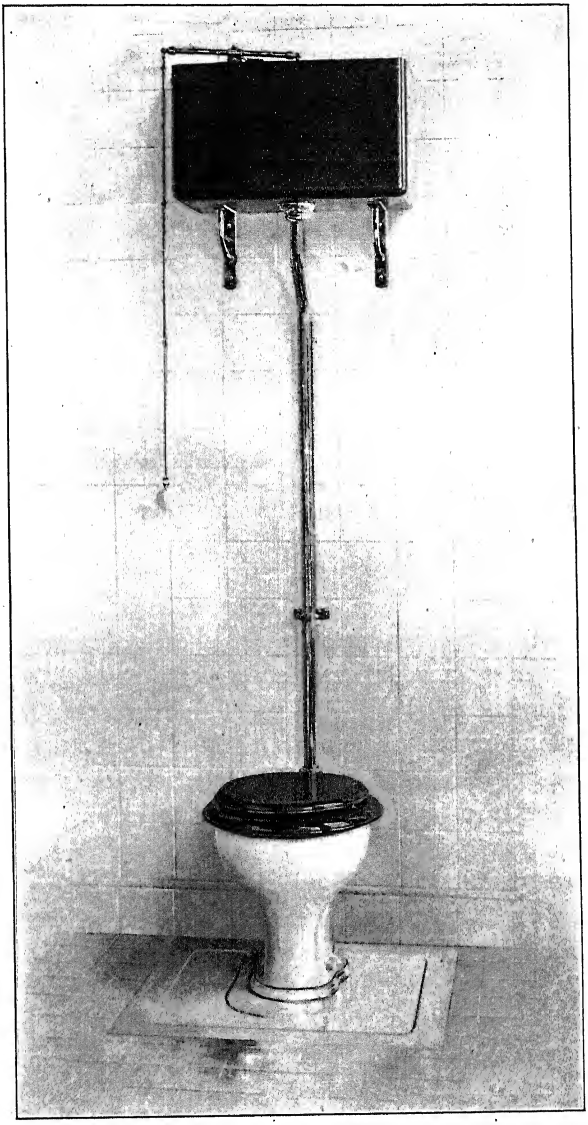

FIG. 87. View of Meyer-Sniffen Co's "Vortex" Siphon-jet Closet.

Hydraulic Specialty Company of Philadelphia. The special features of this closet are that it dispenses with jets in the lower part of the closet bowl. Its flush is instantaneous and strong, and comparative noiselessness is attained by forcing the air contained in the flush pipe out through the outer shaft of the closet into the soil pipe, so

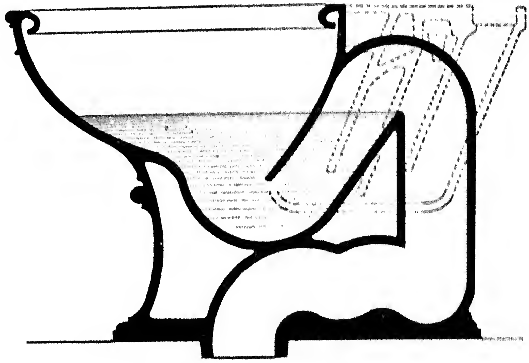

FIG. 88. Section of Pluvic Closet.

that the water entering the flushing rim is free from air. As long as there is water in the bowl, this closet is securely sealed against gases from the soil pipe. One minor advantage of this closet is that it can be worked by means of the discharge of a pail. It is efficiently flushed with a few gallons of water. The appearance of the closet with its flushing cistern is shown in Fig. 89.

Besides the siphon-jet and siphon closets there is another type of closet which is an evolution of the improved hopper closet with water in the bowl. For want of a better name these closets are designated as pedestal wash-down closets, the direct action of the flushing water as it enters the bowl with a downward rush effecting the discharge. A very excellent closet belonging to this class is the "Surety" closet made by the Meyer-Sniffen Company, illustrated in section in Fig. 90.

A wash-down closet very similar in action and appearance is the "Sanic" water-closet manufactured by the Hydraulic Specialty Company of Philadelphia, and shown in Fig. 91. It should be noted that in closets of this type it is important that the water should descend very rapidly into the bowl, hence it is advisable to use a flush pipe of $1\frac{1}{4}$ or even $1\frac{1}{2}$ inches bore. Sometimes, however, they

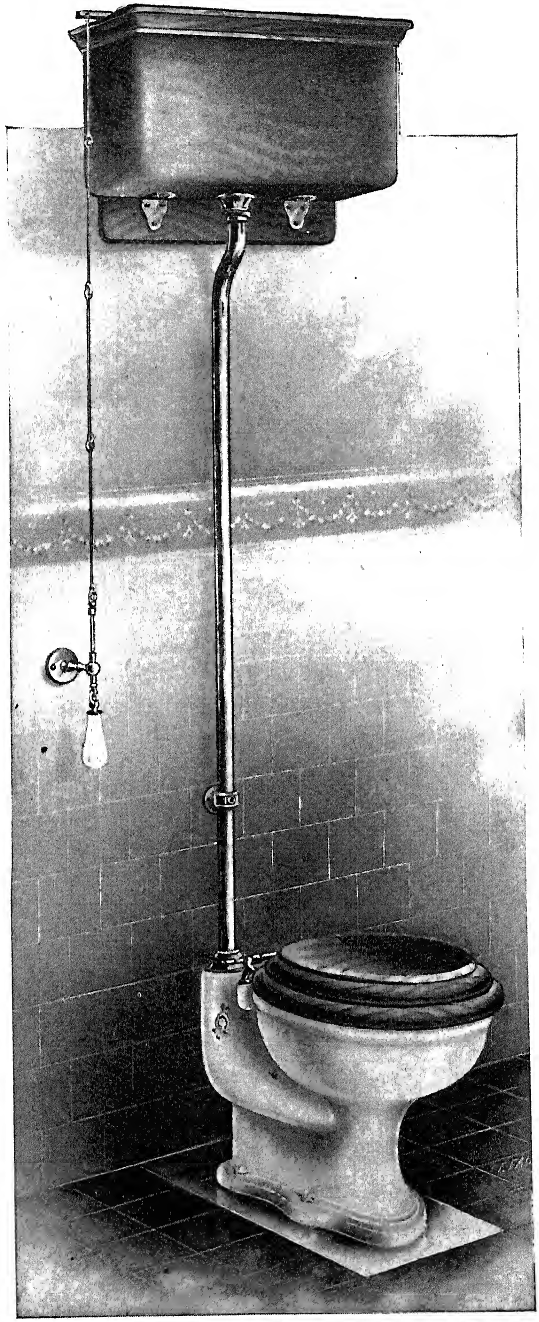

FIG. 89. View of "Pluvic" Closet.

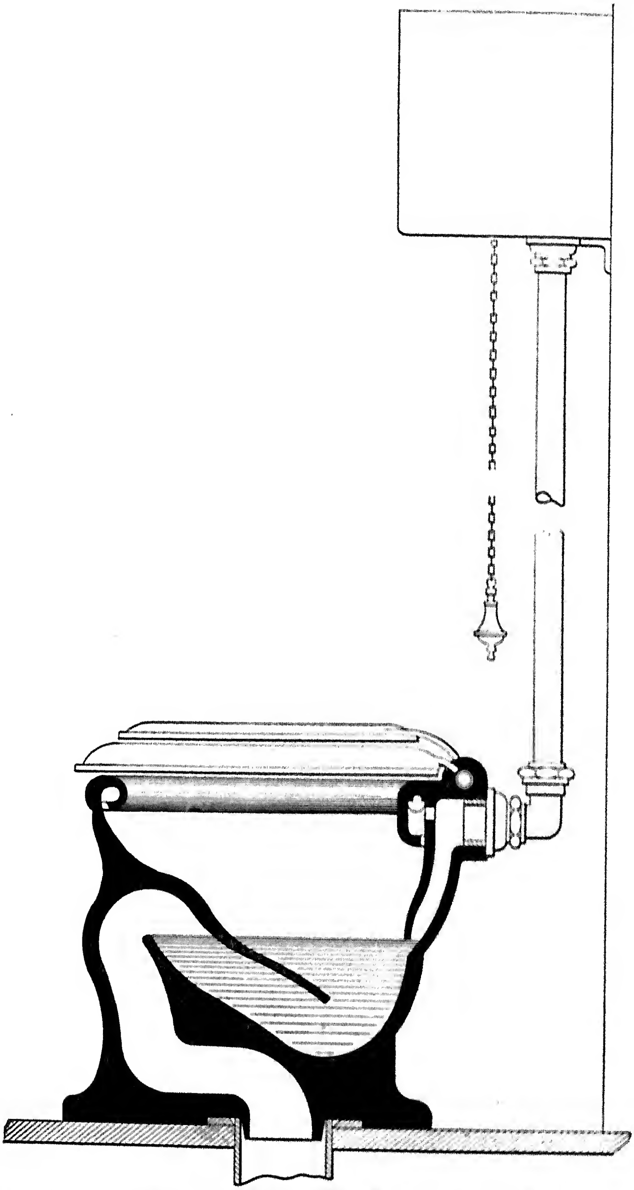

FIG. 90. Section of Meyer-Sniffen Co's "Surety" Closet.

are flushed by a special flushometer valve, as shown in this case.

Besides water-closets having the regulation overhead flushing tanks there have been introduced in recent years two modifications,

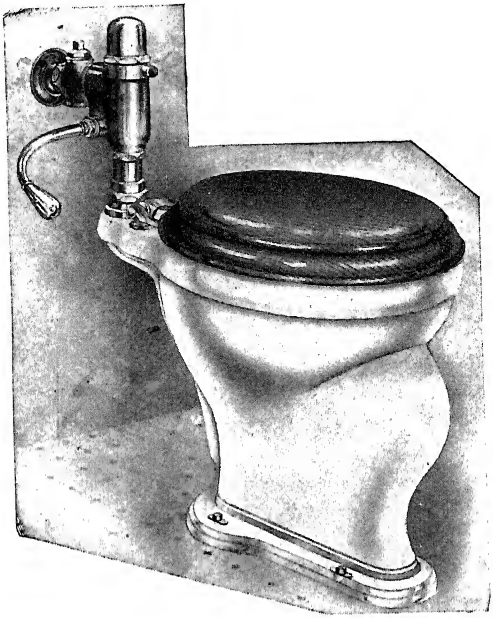

FIG. 91. View of Sanic Closet with Flushometer Valve.

viz., the so-called **"low-down tank" closets** (Figs. 92 and 93), and the closets which have a **flushometer valve** in place of the overhead tank. In my judgment, they have a limited usefulness, such as in situations where the water-closets must necessarily stand under stairs with little head room, or for the upper floors of buildings, where the water pressure is low. I cannot see any good and valid reason for using them altogether in place of the regular closet apparatus with high cistern. I have yet to learn of a good closet with a good overhead tank which has failed to work well and to give continued satisfaction while requiring but small repairs or none at all. There are fads in everything, and my impression is that the preference given in certain quarters to a flushometer closet must be accounted for as being merely a passing fad.

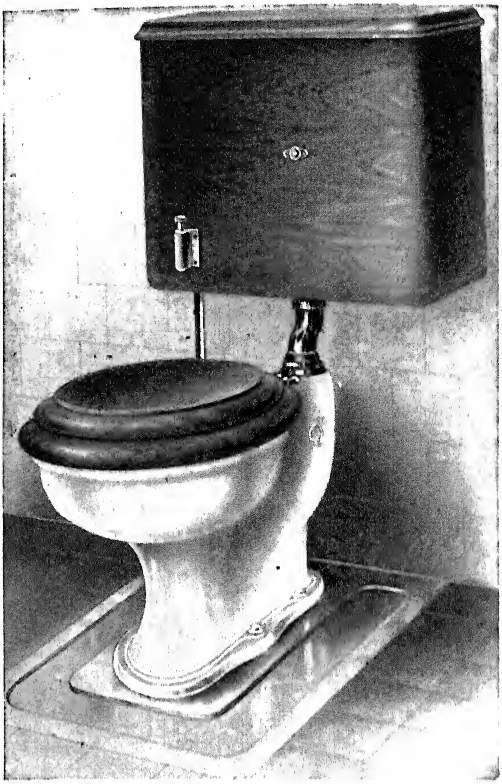

FIG. 92. View of Hydric "Low-down Tank" Closet.

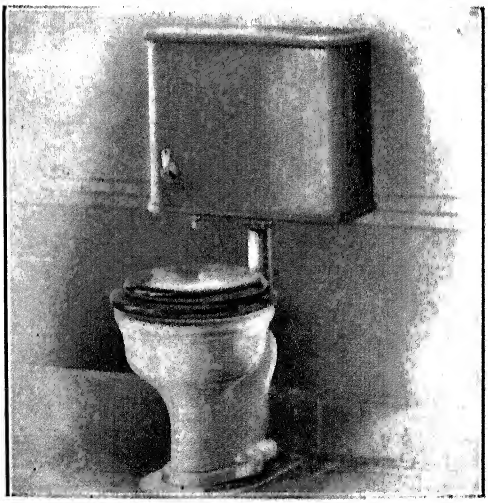

FIG. 93. View of Mott's Latona "Low-down Tank" Closet.

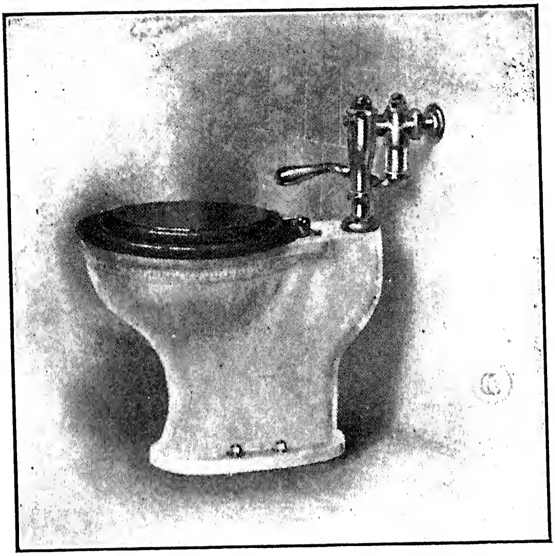

FIG. 94. View of Crane Co's Flush-valve Closet.

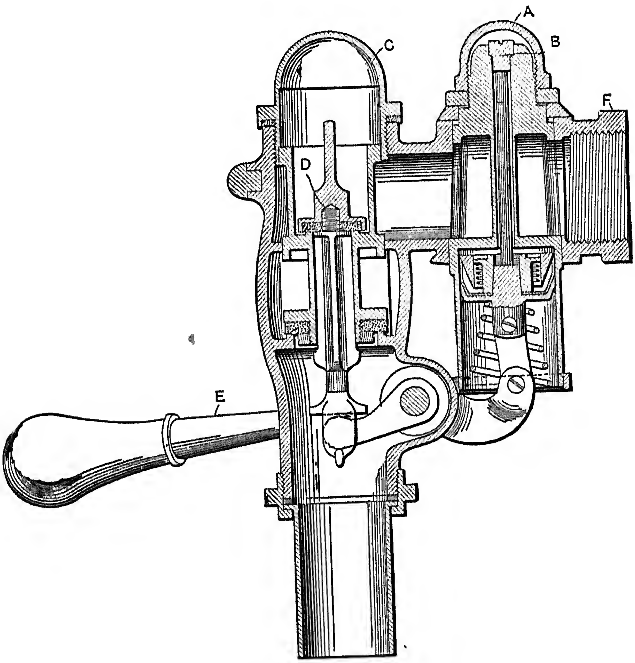

FIG. 95. Sectional View Boston Flush-valve.

Flushometer Valves. — The Boston flush-valve closet (Fig. 94) made by the Crane Company of Chicago is claimed to be one of the best of its kind. Many flushometer valves have been put on the market with varying success where the water was fairly clean,

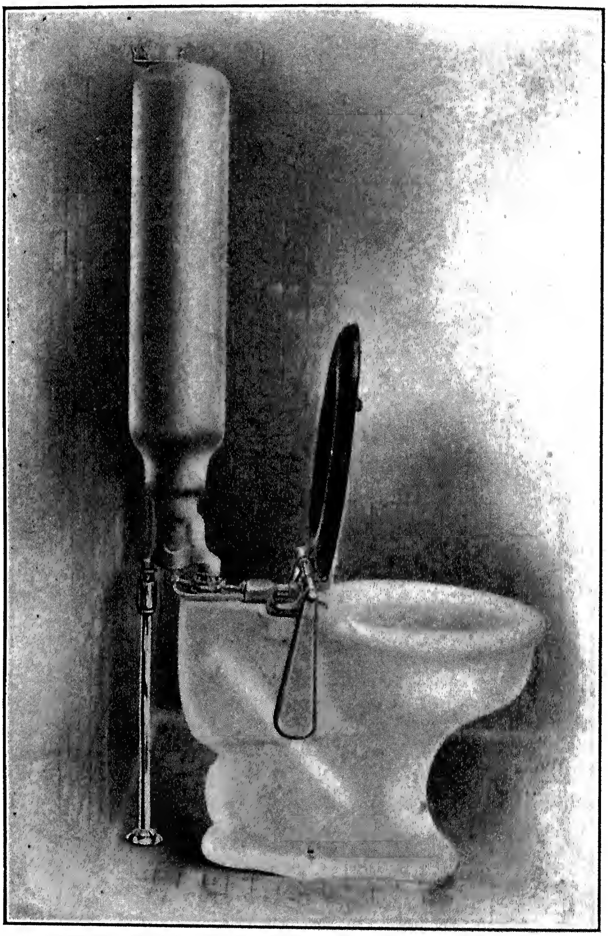

FIG. 96. View of "Unique" Water-closet with Closed Tank for Flushing.

free from grit, alkali or alum. All such valves have been constructed practically upon the same principles.

A sectional view of the Boston flush valve is shown in Fig. 95. This valve is claimed to work just as well on dirty or muddy water as it will on filtered water, because there are no small by-passes

to stop up or close fits to corrode, and it does not make any difference whether the water contains alkalies or not. It can be regulated to any length of flush desired without shutting off the water.

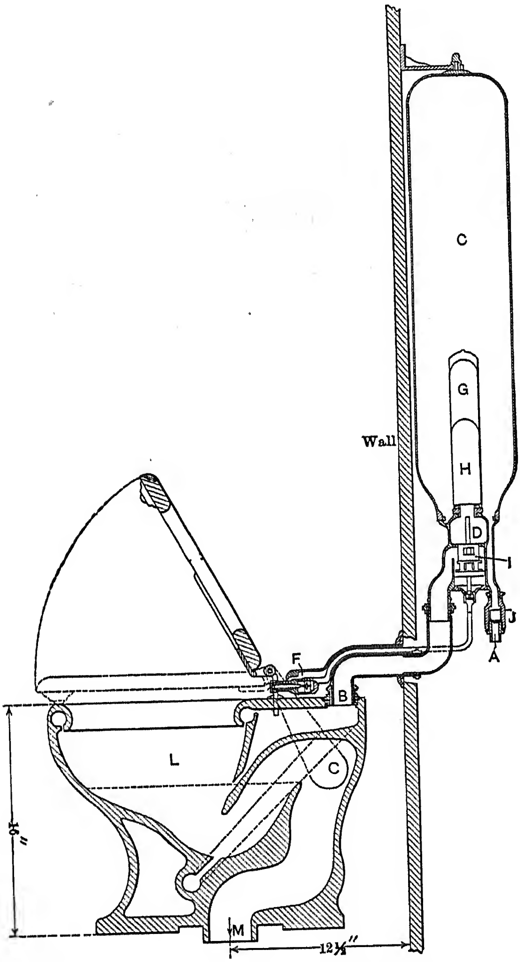

FIG. 97. Sectional View of "Unique" Water-closet with Supply Tank Placed behind a Partition.

The working parts of the valve may be removed simply by unscrewing the cap *C*.

Figs. 96 and 97 show another novel form of flushing device for a water-closet. The bowl of the closet is much the same as other

bowls, but the difference consists in the device intended for flushing. Instead of an overhead flushing tank, or a low-down tank, or a flushometer valve, the "Unique" water-closet, manufactured by the Staples Valve Company of Newburgh, N. Y., provides a closed metal cylindrical tank as shown.

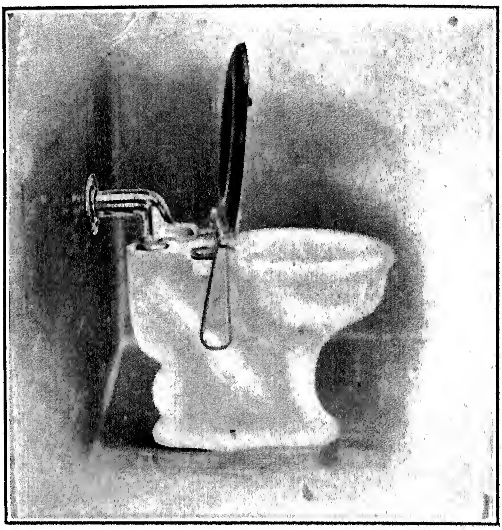

FIG. 98. View of "Unique" Water-closet Showing Seat Action.

It is connected with the supply pipe through inlet A (Fig. 97) and is operated by pressing down the handle C, which must be held a short time and released. When the handle is pressed down water passes through the auxiliary valve F under plunger I, lifting the plunger until it touches float H, which immediately rises to the top of the inner chamber G, opening the outlet from the tank. The compressed air above the water in the tank E forces the water down into chamber D, the plunger returns to its original position and the water passes out into the flushing-rim of the bowl through outlet B. The device operates successfully only where the pressure is more than 10 pounds, and according to the pressure two different sizes of tanks may be selected. The valve may be operated by hand or else it may be made automatic by being connected with the seat.

As shown in Fig. 98 this style of closet lends itself particularly to conditions where it is desired to hide the flushing tank from view. It is said that this closet, if properly installed, is absolutely

noiseless in action. It uses from $3\frac{1}{2}$ to $4\frac{1}{2}$ gallons of water at each flush, and being made in one piece of metal it is not so liable to leak as box tanks. It has only a few working parts and is said not to get out of order easily.

Closet Bowls with Local Vent.—Sometimes the water-closet bowls are provided with **local ventilation,** the vent outlet being connected with a heated flue, as shown in Fig. 99.

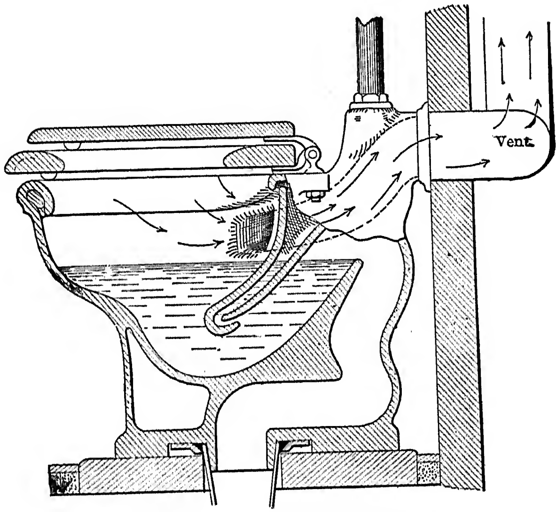

FIG. 99. Section of Water-closet with Local Vent.

General Arrangement of Water-closets.—The manner of setting the water-closet in the bath or toilet room is of much importance. Simplicity in arrangement and entire accessibility of the fixture and its surroundings are the chief requirements. To accomplish both, I long ago advised putting as little woodwork about the fixtures as possible. All that is required is a well-made hardwood seat, preferably without cover.

Water-closet Seats.—The old-fashioned square-box water-closet seat with frame and riser in front of the bowl is now quite obsolete. If a **full seat** is desired, it should be supported on the side walls by means of nickel-plated crotches fastened to the wall (Fig. 100). The seat should be arranged so it can be lifted out of the crotches to expose the entire water-closet apparatus. This permits of turning

the seat out of the way when the closet is not in use, thus leaving the fixture exposed so as to be readily cleaned. The same arrangement makes a closet serviceable as a urinal for male persons.

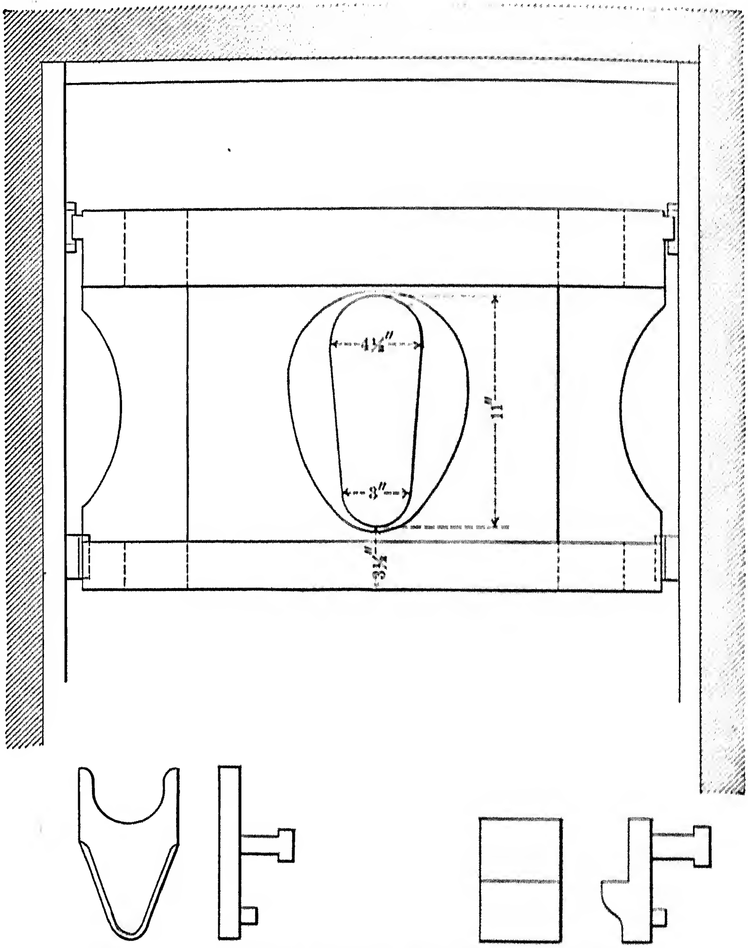

FIG. 100. Detail Plan of Full-size Water-closet Seat.

Some years ago a porcelain drip tray was fitted up in connection with the square frame seat to prevent spillage, but I consider this an unnecessary appendage to an open-set water-closet, it being just as objectionable from a sanitary point of view as the wooden riser.

In the past few years it has become customary to attach the wooden seats directly to the porcelain closet bowl by means of nickel-plated brass posts and brass hinges so that the seat can be swung back and out of the way. In the illustrations are shown several forms of modern apparatus having such a **sanitary seat arrangement.**

Regarding the shape and dimensions of the hole in the seat, there is still noticeable a tendency to make the hole too large. One of the most comfortable and hygienic seats of which I have knowledge is made of shape and dimensions as shown in Fig. 101.

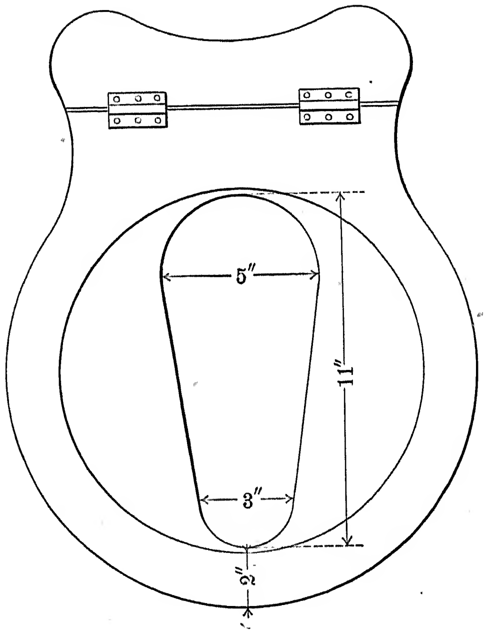

FIG. 101. Water-closet Seat of Approved Dimensions.

In connection with the arrangement of water-closet seats, some special devices and types call for brief mention. In the use of a closet quite often some urine is spilled over, and with the modern open arrangement of fixtures this has led to undesirable conditions at the foot or base of the closet. Formerly the same trouble was apt to occur, to be sure, but it did not show then, though it led just the same to unsanitary conditions inside of the box enclosure of the

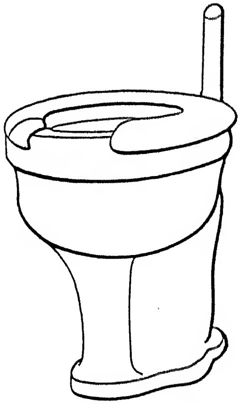

FIG. 102. Front View of Mott's Special Form of Water-closet Seat.

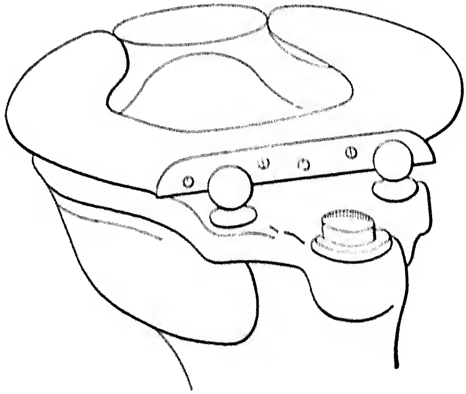

FIG. 103. Rear View of Mott's Special Form of Water-closet Seat.

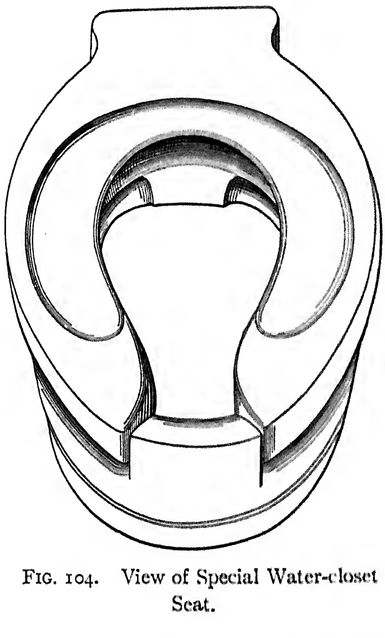

FIG. 104. View of Special Water-closet Seat.

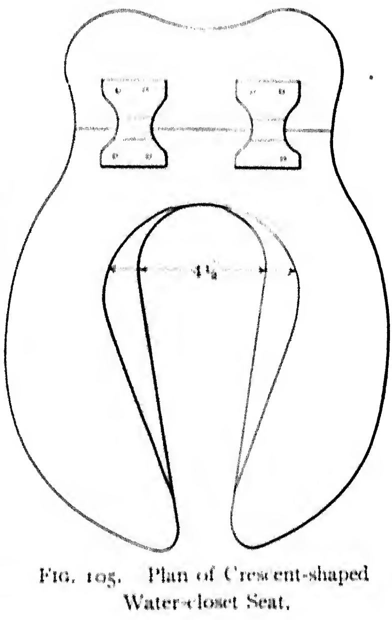

FIG. 105. Plan of Crescent-shaped Water-closet Seat.

fixtures. Recently several attempts have been made to overcome this defect.

Some closets, like the "Titan-Sano" and the "Beekman-Sano" of the J. L. Mott Iron Works (Figs. 102 and 103), have a special form of seat, in which the front portion of the woodwork is cut

out and the bowl so shaped at the front and top of the closet as to substitute porcelain for the wood. This raised porcelain part is intended to prevent the soiling of the front part of the seat and of the floor. Incidentally it provides another important sanitary feature by reducing the danger of bodily contagion to a minimum. This form of closet seat was originally devised by a woman (see Fig. 104), and it is now in use in many women's toilet rooms of hotels, department stores, railroad depots, hospitals and office buildings. A similar seat without the raised porcelain part is shown in Fig. 105.

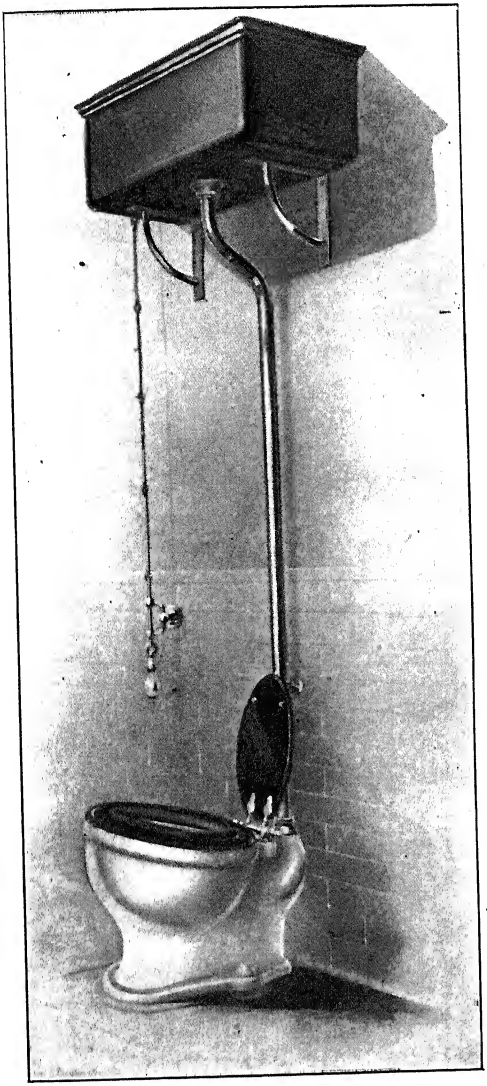

FIG. 106. View of "Naturo" Closet.

Another form of water-closet bowl, differing from the standard form and embodying a novel idea, was brought out a few years ago. It is illustrated in Figs. 106, 107 and 108, and is known as the "Naturo" closet. Instead of having the usual horizontal form of water-closet seat, this closet provides a seat with a backward slant, that is, the bowl and seat are higher in front than in the rear, and at the same time the bowl and seat are lower than the normal ones

(see Fig. 106). The inventor claims — and many physicians and surgeons confirm his views — that a high seat is not only uncomfortable and leads to a cramped position of the body, but that it is physiologically incorrect, because it causes a constriction of

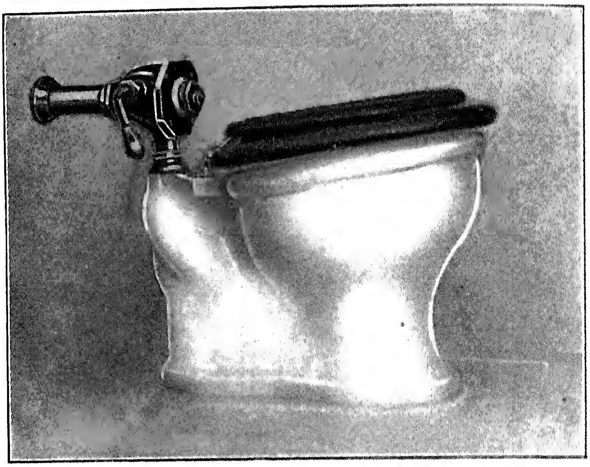

FIG. 107. View of "Naturo" Closet.

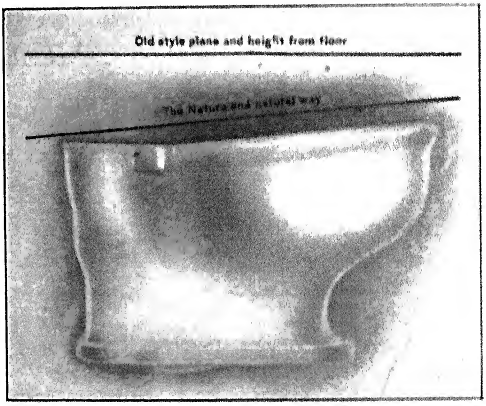

FIG. 108. View Illustrating Slant of "Naturo" Water-closet Bowl.

the long intestine or descending colon. The "Naturo" closet differs from the ordinary closet in the shape of the slanting bowl and seat, which compel the user to assume a physiologically correct position when seated, *i.e.*, a posture which favors an easy and

complete evacuation of the rectum. It is said that gynæcologists also approve of the principles upon which the "Naturo" closet is based, for reasons which it is not necessary to explain here.

An incidental advantage gained by the use of the slanting form of bowl and seat is that in micturition in a sitting position, both by male and female persons, the front of the bowl, being raised higher, forms a protection and a safeguard against the wetting of the seat, and against the spilling of urine over the front top rim of the bowl, which so commonly occur with the usual closet bowls. From personal observation I can assert the fact that this is accomplished very satisfactorily, and thus another advantage from a sanitary point of view is attained, which is at least equal to that of the form of water-closet bowl described before.

Floor and Walls of Water-closet Compartments.—The **floor** and the **walls** of a **water-closet apartment** look best when finished with plain white glazed tiles or with marble slabs; both arrangements are much superior, though more costly, than wooden wainscoting. Where economical reasons do not permit the expenditure required for tiling or marble, a slab of slate forms a good floor, and for the simplest and plainest kind of work a narrow well-jointed hard-wood floor answers all purposes, though it is even then wise, and required by some building or plumbing regulations, to use a narrow marble or glazed porcelain slab directly under the fixture.

The Slop-hopper or Slop-sink.—An open arrangement of the water-closet fixture permits its use as a slop-hopper, and it is important in cases where such use is made of the water-closet to instruct the servants to flush the fixture each time slops are poured through it. The occasional use of a water-closet as a slop-hopper assists in preventing its sides from becoming befouled, particularly in case of the dry hopper closets. Nevertheless I do not desire to be understood as being opposed to the use of **special slop-water apparatus** in every case. I consider them a necessity in hospitals, hotels, large boarding houses, clubhouses, and in the better class of private residences, where each bedroom is generally provided with its own separate bath-room. In this case a housemaid's compartment must be provided on the bedroom floor which should contain a slop-sink.

The objectionable pan, valve and plunger closets could not be

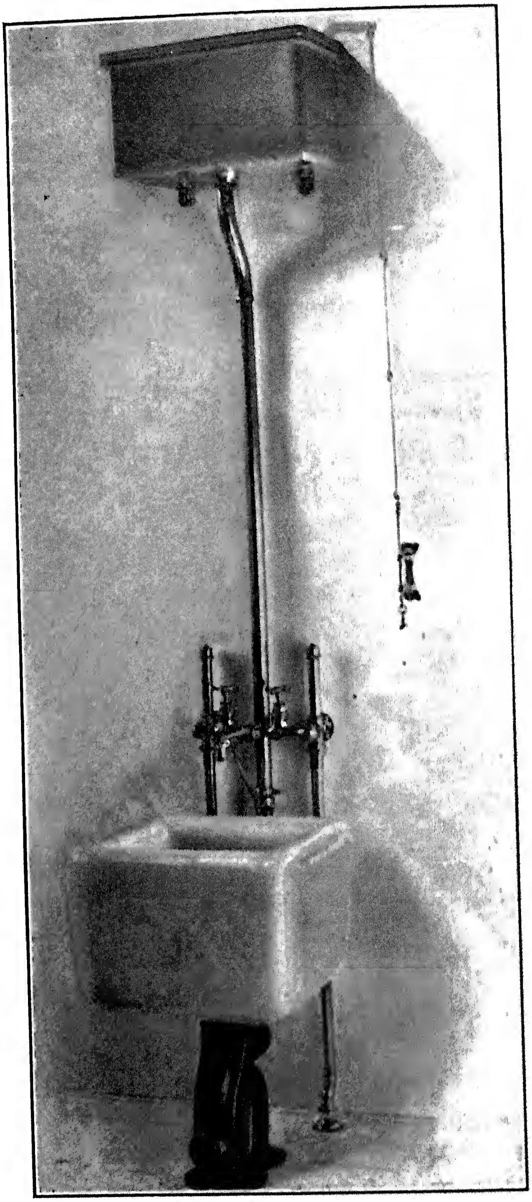

FIG. 109. View of a Flushing-rim Slop-sink.

used for the pouring out of slops, as their overflow passages necessarily became filthy from such use. In private residences, fitted up with freely exposed improved modern types of water-closets having no mechanical obstructions in the bowl, and presenting a large and free waterway into the drain, a slop-sink or slop-hopper may, in some cases, be considered a superfluous fixture.

But, if a slop-sink is used, it should preferably be of the type which has a flushing-rim and a regular flushing cistern with flush pipe connected with the top of the sink, such as shown in Fig. 109. Such a fixture always requires a strainer, generally an open strainer, to prevent the obstruction of the trap. The latter is formed in the shape of a standard and answers as a support of the slop-sink proper. The sink should be provided with single or combination faucets for hot and cold water and with a flush pipe coming from the overhead tank. These fixtures are obtainable in enameled iron or of porcelain, which latter are possibly more durable; but best of all are the new roll-rim earthenware slop-sinks, made in one piece of heavy glazed ware and having the top provided with a flushing-rim molded in the sink.

The Urinal. — For private residences the **urinal** seems to be the least desirable of all fixtures. Although really superfluous and always objectionable, this fixture is still found in some of the larger dwellings. I have already indicated how a water-closet, fitted up with a hinged seat and entirely open in accordance with the most modern ideas, may be perfectly well used as a urinal.

It is quite different in the case of hotels, railroad stations, clubhouses, and places of amusement. Here the fixture is a necessary one in the toilet rooms intended for the general public (see Fig. 110).

A urinal fixture must be flushed with an abundance of water in the most thorough manner, and it is always desirable that the fixture itself into which the urine is discharged, should contain water, so as to dilute the urine. A form of urinal intended to offer these advantages is shown in Fig. 111. The trap is in this case molded in one piece with the bowl. Several new styles of urinals are molded much on the principle of the siphon-jet closet and have a very powerful flush which thoroughly cleanses the fixture. My experience with urinal fixtures has been that those

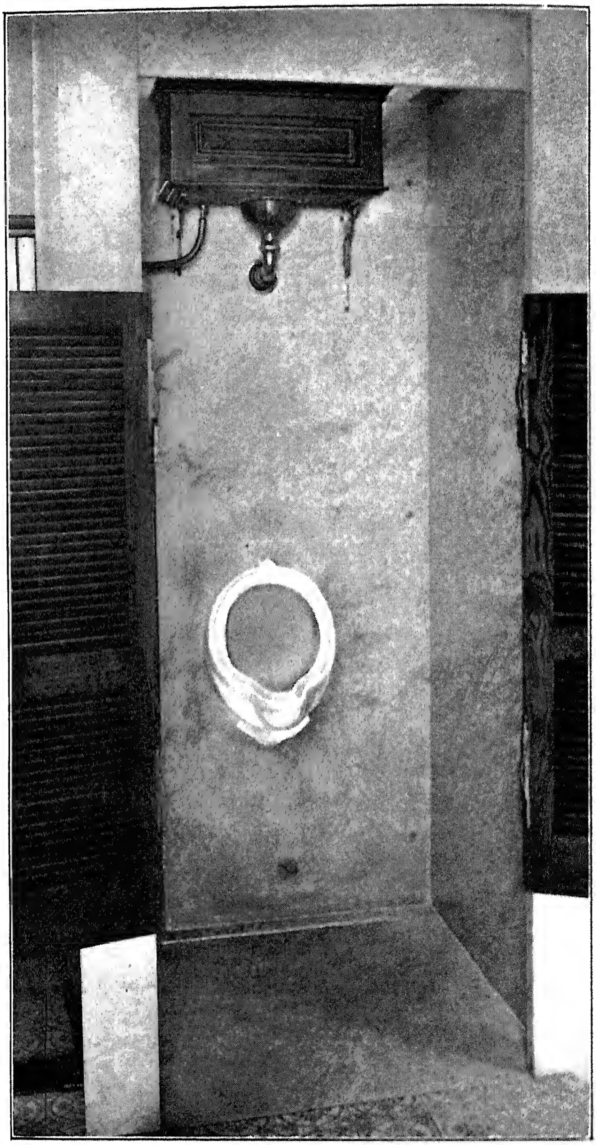

FIG. 110. View of Urinal.

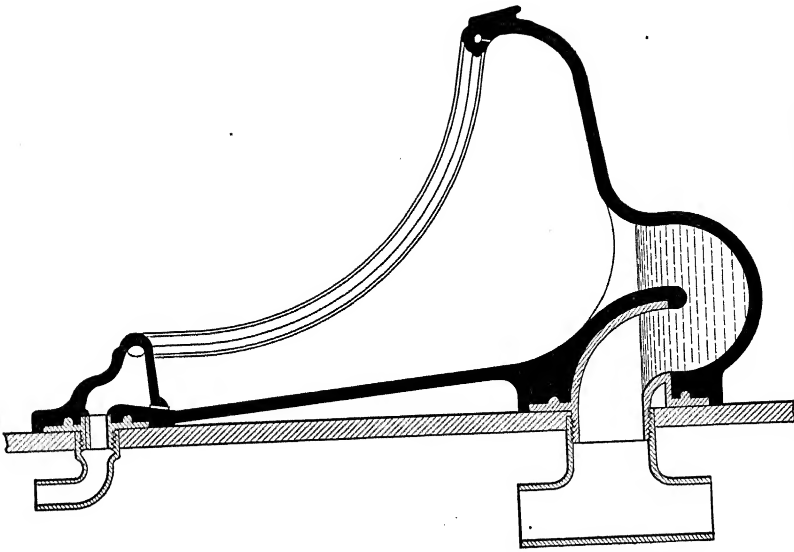

FIG. 111. Section of Improved Urinal.

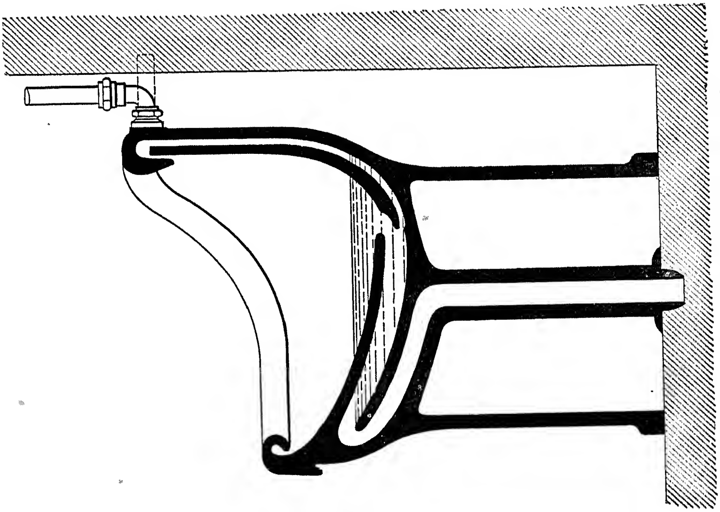

FIG. 112. Section of Pedestal Urinal.

not provided with a lip in front keep cleaner, as the user will stand nearer. Another help in securing a clean urinal stall, free from drippings on the floor, is to set the urinal low, not more than twenty inches from the floor to the top of the front of bowl.

A novel form of urinal apparatus is shown in Fig. 112. It is a pedestal urinal, with bowl holding water. This form of urinal was first brought out by the Meyer-Sniffen Company. As shown in the view, Fig. 113, the urinal is made of earthenware in pedestal form, and stands entirely free from the wall on the floor. This does away with the joint between the usual form of urinal and the wall, and permits the easy cleaning of the entire fixture. The bowl, as shown in section, is formed very much like the bowl of a siphon-jet closet, and the discharge of the urinal is effected by means of the jet supplied from the overhead tank. Another advantage claimed for this style of urinal fixture is that the user will stand closer to the fixture, thereby insuring greater cleanliness. A further possible advantage is that owing to its peculiar shape the fixture seems adapted to used as a urinal by both men and women.

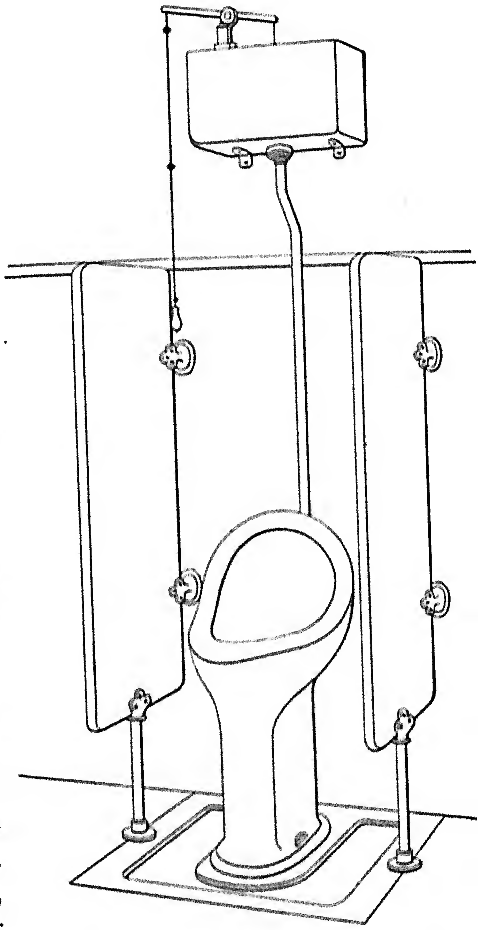

FIG. 113. View of Pedestal Urinal.

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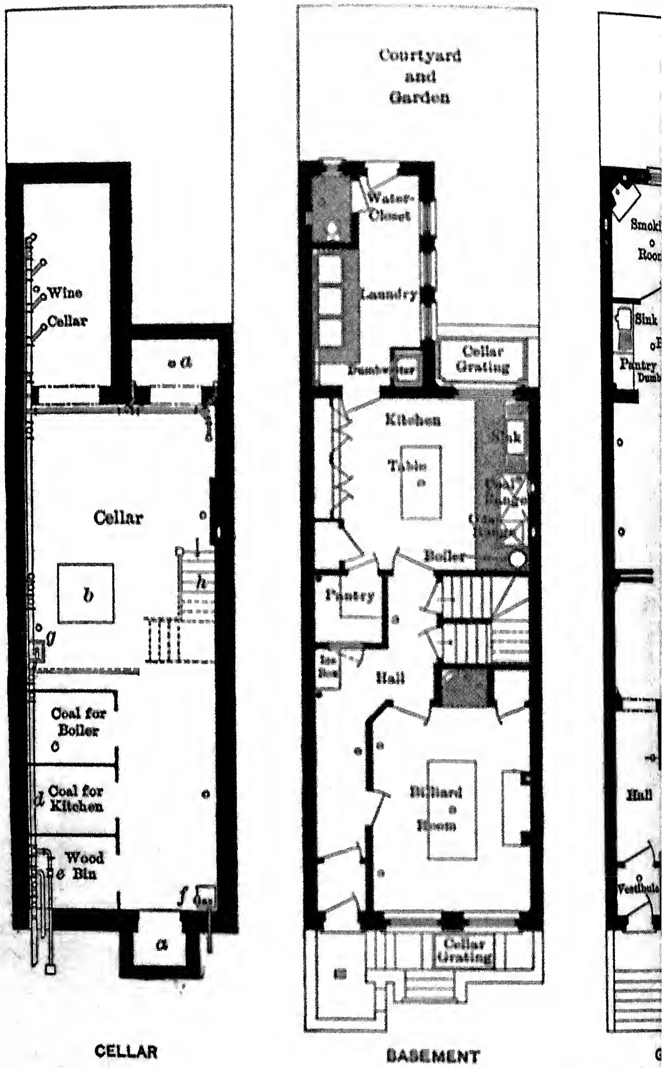
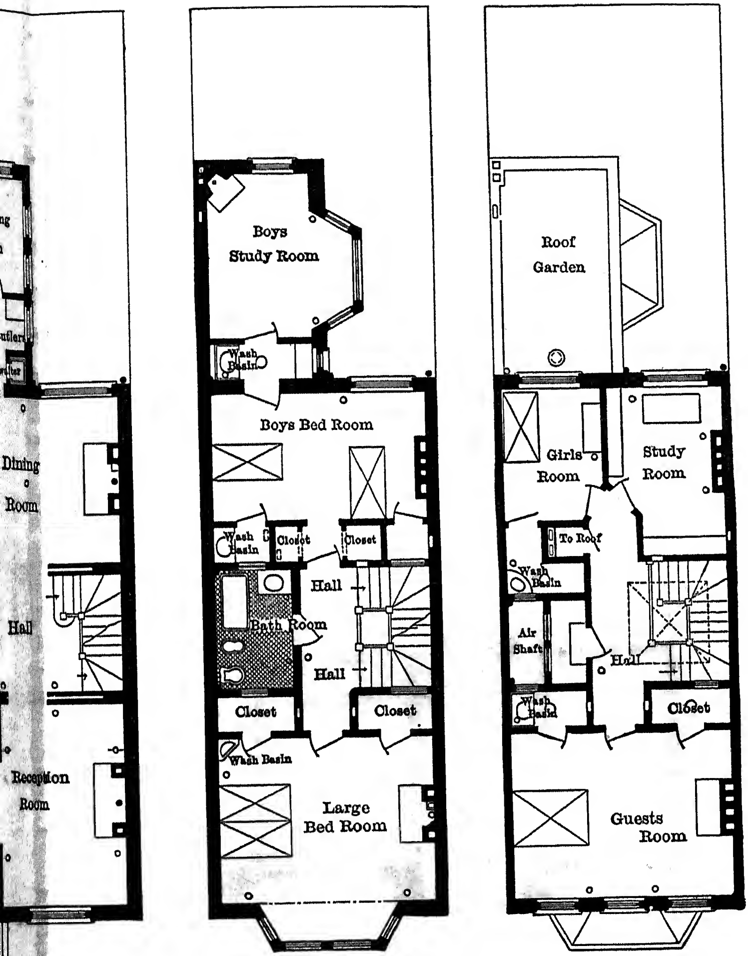


FIG. 114. Floor Plans



ROUND FLOOR FIRST FLOOR SECOND FLOOR

f a City House Showing Plumbing.

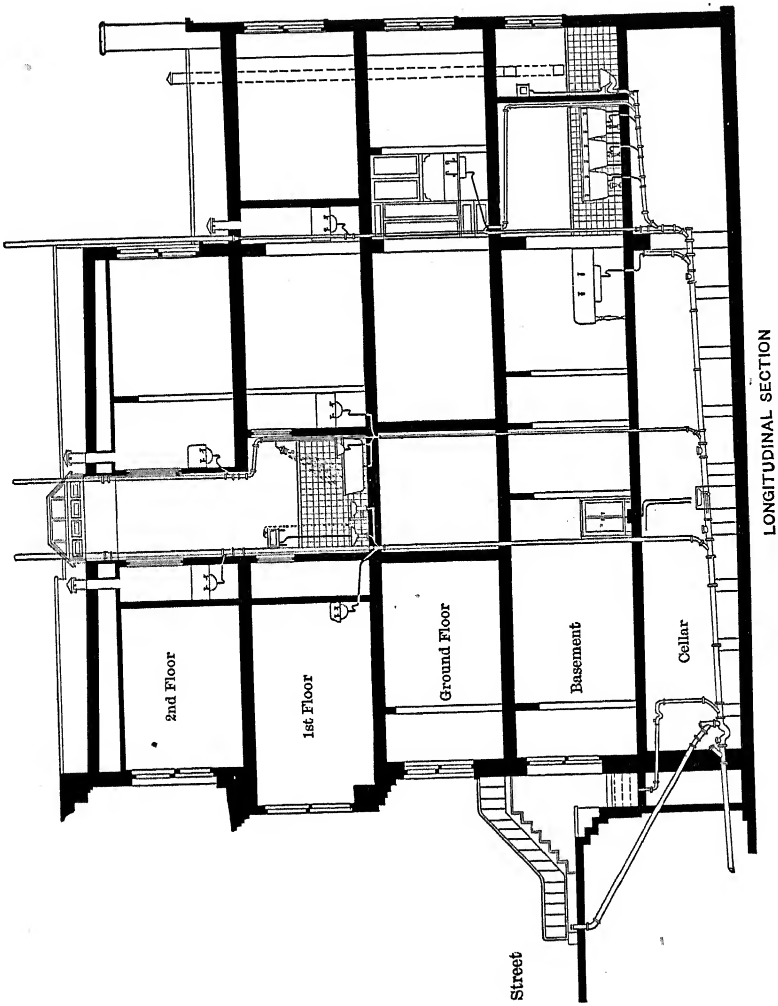


FIG. 115. Section of a City House Showing Plumbing.

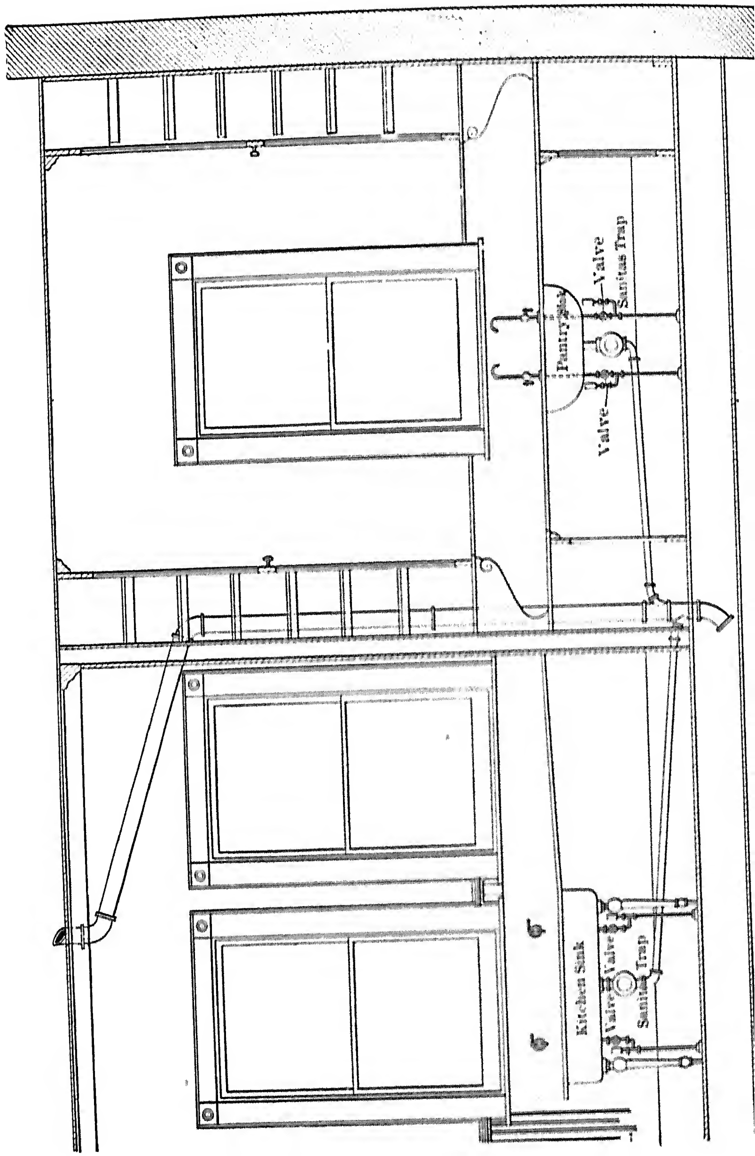
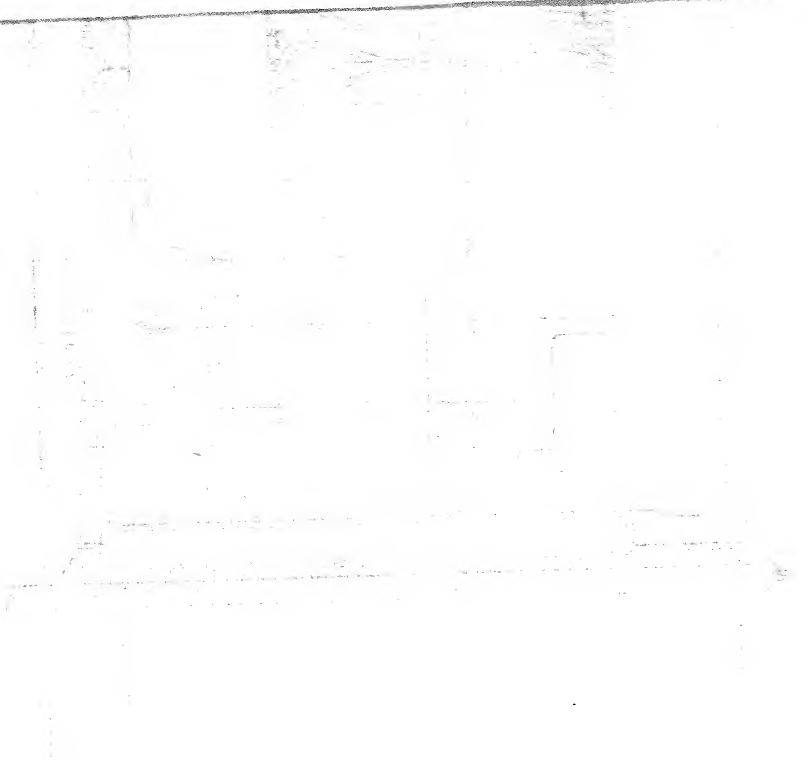

Valve
Sanitas Trap
Pantry Sink
Valve
Kitchen Sink
Valve
Valve
Sanitas Trap

Fig. 116. Plumbing Connections for Kitchen and Pantry Sinks.



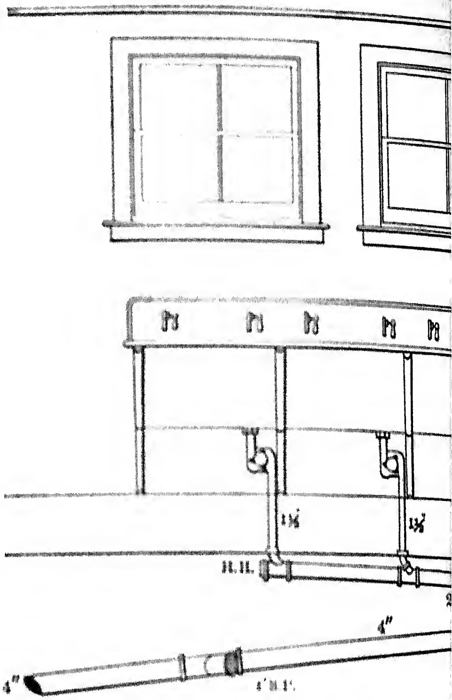
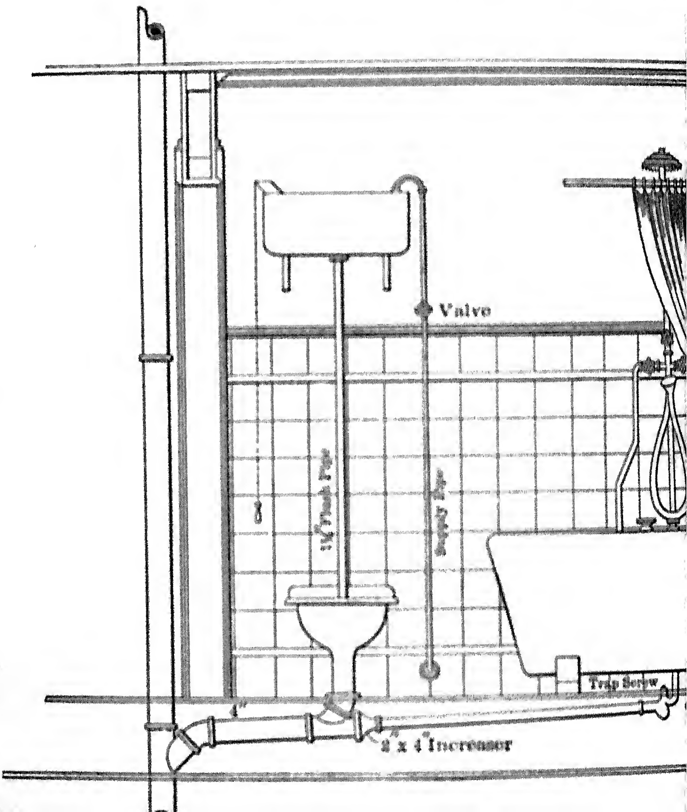
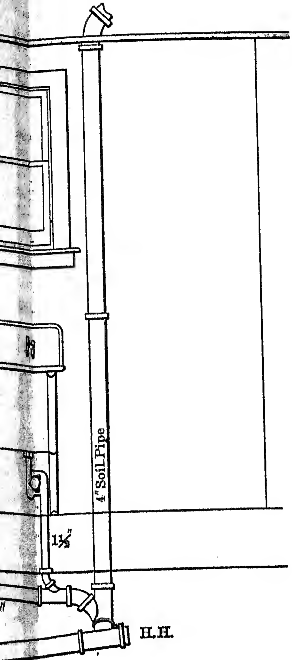
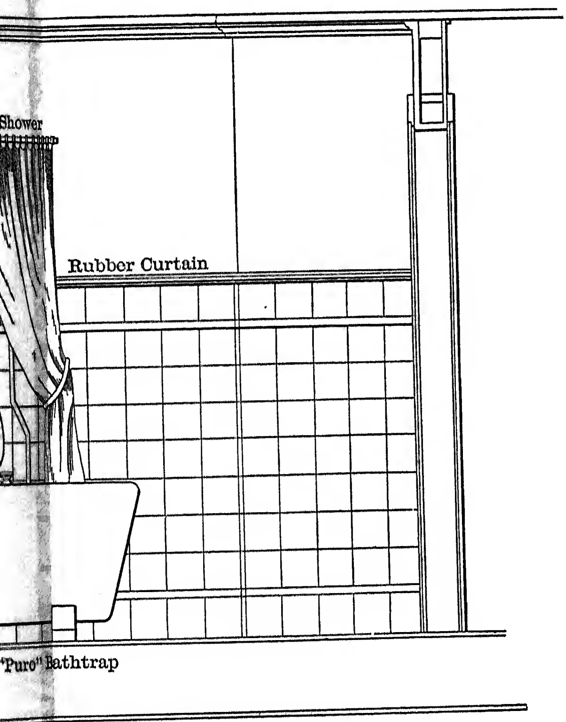


FIG. 117. Plumbing Connections





for Laundry Tubs.



For public buildings the best form and type of urinal available is the solid porcelain stall urinal in niche form, with base and platform of glazed earthenware, and provided with large strainer and waste pipe.

General Arrangement and Connection of Plumbing Appliances with the Plumbing and House Drainage System. — It is not necessary in this chapter to give a minute description of how the sanitary appliances of a building are connected with the drain and soil-pipe system, how this system is efficiently ventilated, and how the fixtures are trapped in a safe manner so as to prevent sewer air from entering the apartment where the fixture is located, for the elements of a system of house drainage and the proper arrangement of soil, waste and vent pipes have been discussed in Chapter I.*

A few illustrations are introduced here for the sake of explanation. Fig. 114 shows the **plans** and Fig. 115 the **section of the plumbing of a city house.**

Fig. 116 shows the **plumbing connections** for a kitchen and an adjoining butler's pantry sink, and Fig. 117 shows the plumbing of a set of laundry tubs. The plumbing connections for bath rooms are shown in two examples, Figs. 118 and 119, and Fig. 120 shows the plumbing for a single washstand, while Fig. 121 shows a set of two adjoining lavatories. This last arrangement is the only one showing back-vented traps; all other figures are examples of the one-pipe system in connection with non-siphoning traps. (See Chapter III.)

Finally I give in Figs. 122–125 typical **views of modern bath rooms.** Figs. 124 and 125 are taken from a well-illustrated booklet of the Standard Sanitary Manufacturing Company of Pittsburg, which firm makes a specialty of high-grade enameled iron fixtures. Figs. 122 and 123 are from a similar book, issued by the J. L. Mott Iron Works of New York, who are chiefly manufacturers of fine solid porcelainware fixtures.

These various groups of sanitary bath rooms exhibit the latest and highest types of plumbing appliances in the market. The

* For a detailed discussion of the various kinds of traps and methods of trapping pipes and house drains the reader is referred to the author's larger work "Sanitary Engineering of Buildings," and to his booklet "House Drainage and Sanitary Plumbing."

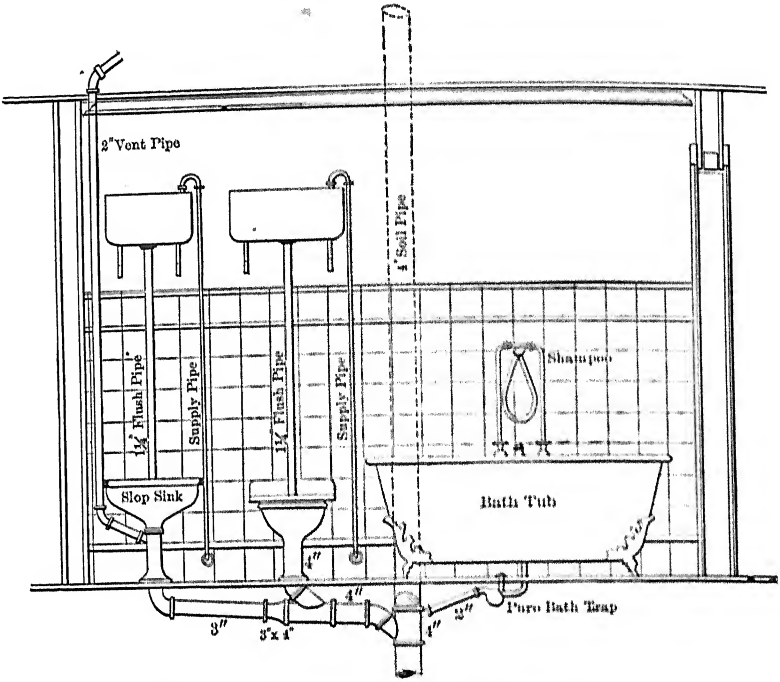


FIG. 119. Plumbing Connections for a Bath Room.

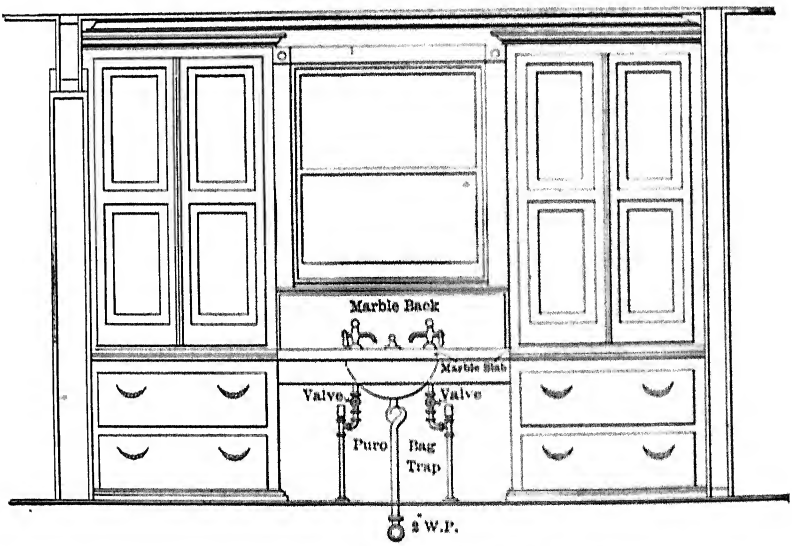


FIG. 120. Plumbing Connections for Washstand.

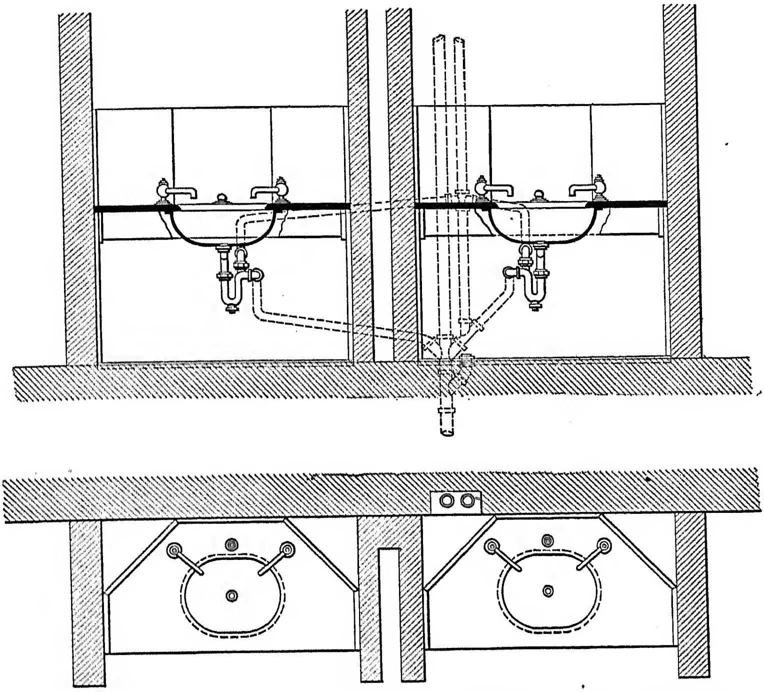


FIG. 121. Plan and Section Showing Pipe Connections for Two Washstands.

plumbing of some of these rooms is plain and inexpensive, as for instance that of Fig. 122a and Fig. 124b, while that of others is very rich, ornate and elaborate.

Fig. 122a is a splendid example of a bath room having a minimum of space but fitted with all necessary conveniences. About four hundred such bath rooms were installed a few years ago under the writer's direction in a prominent hotel in New York City.

Figs. 123a and 124a illustrate the arrangement of the water-closet in a ventilated compartment separate from the bath room proper, advocated by the author as desirable and preferable where the available room permits of it.

Elaborate bath-room plumbing is shown in Figs. 122b and 123b. One of the handsomest rooms is perhaps the one shown in Fig. 122b, a small plan of which appears also in the illustration. This is a room of much more liberal dimensions and permits the use of a porcelain lavatory of extra large size and of a white porcelain bath-

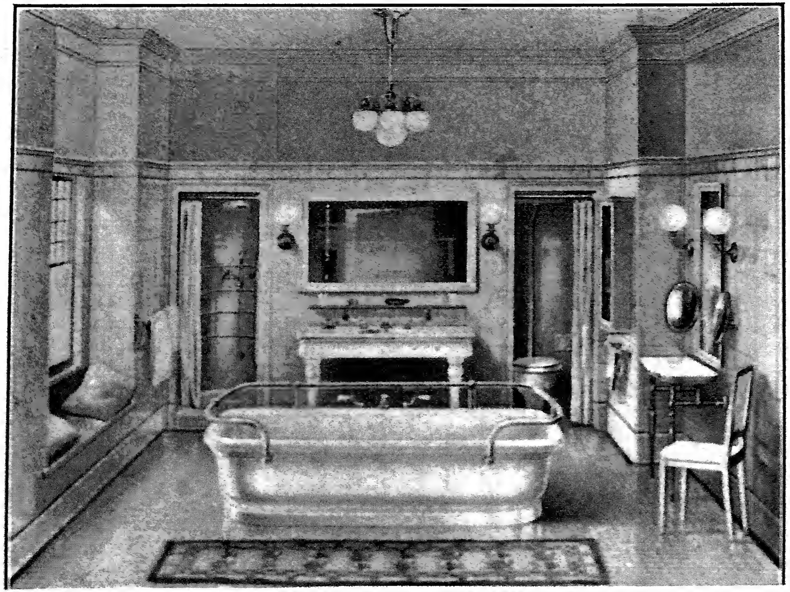


Fig. 122b.

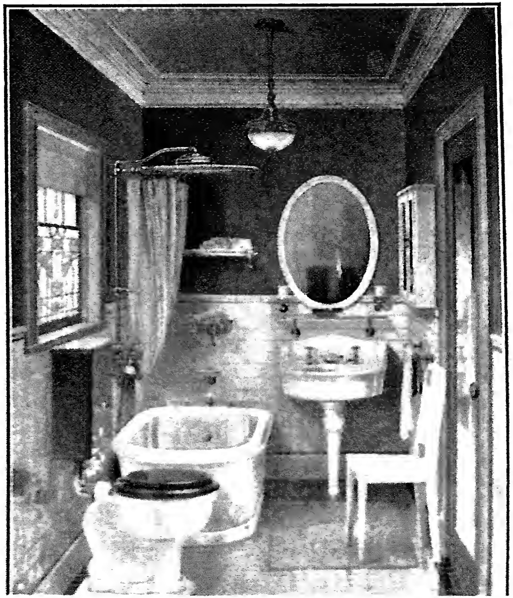
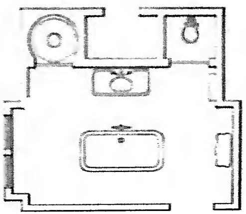


Fig. 122a.



Two Views and One Plan of Modern Bath Rooms,
Taken from Catalogue of J. L. Mott Iron
Works, N. Y.

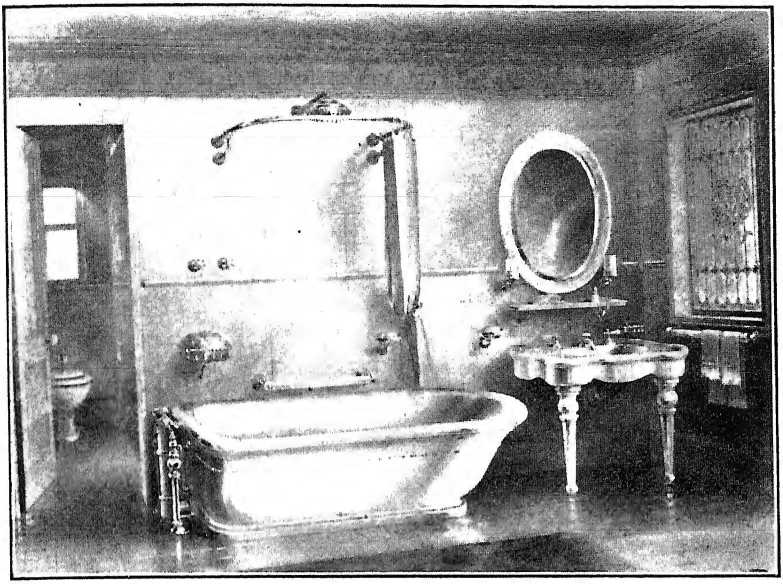


FIG. 123a.

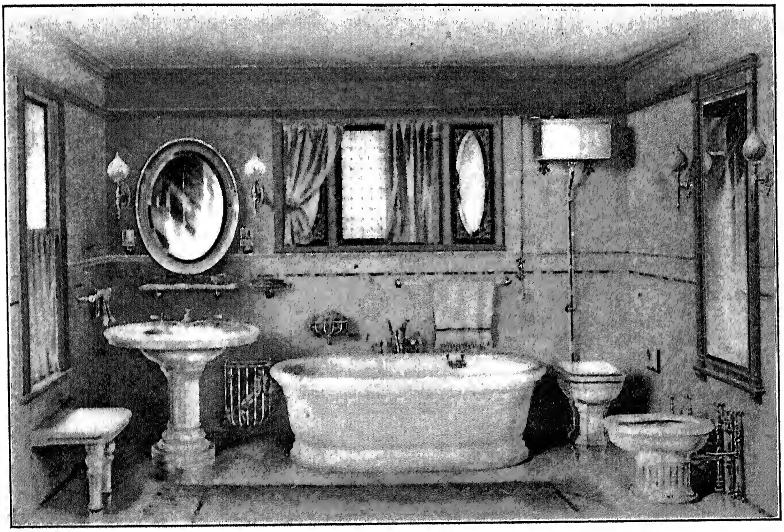


FIG. 123b.

Two Views of Modern Bath Rooms, Taken from Catalogue of J. L. Mott Iron Works.

FIG. 124a.

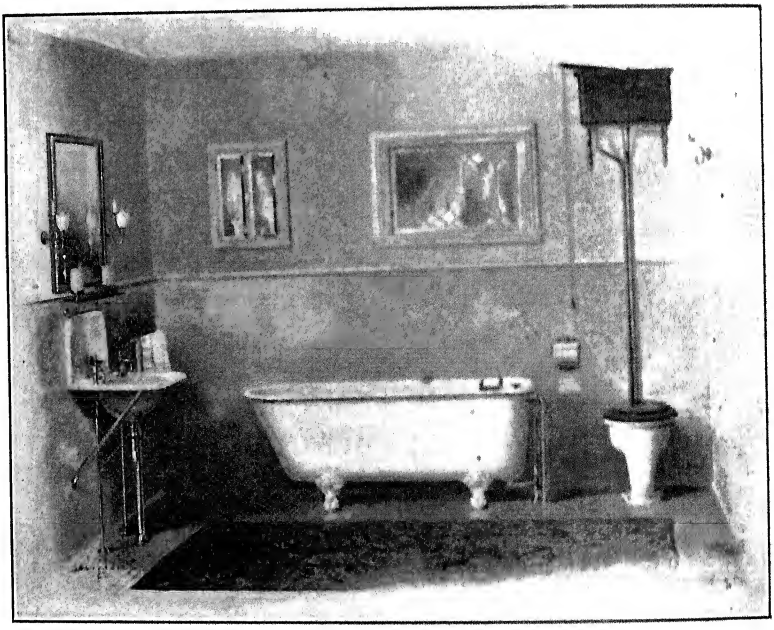


FIG. 124b.

Two Views of Modern Bath Rooms, Taken from Catalogue of Standard Sanitary Mfg. Co., Pittsburgh, Pa.

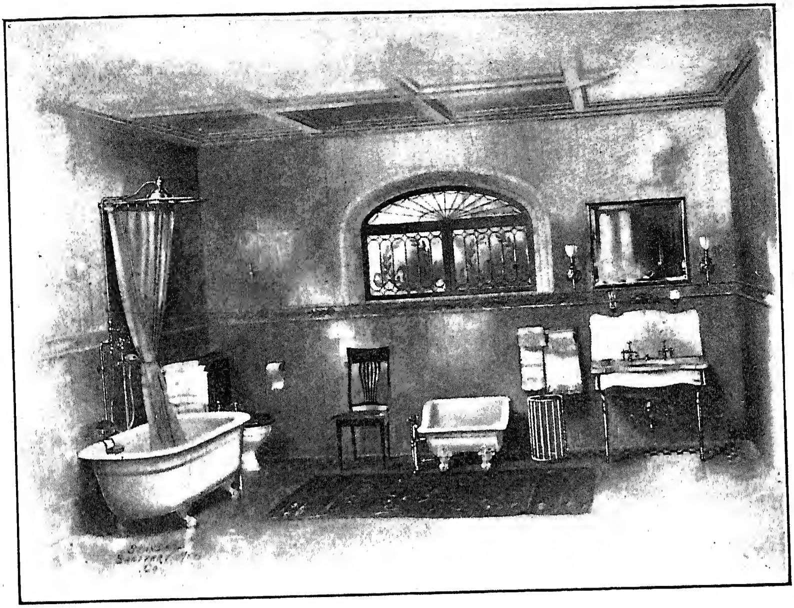


Fig. 125a.

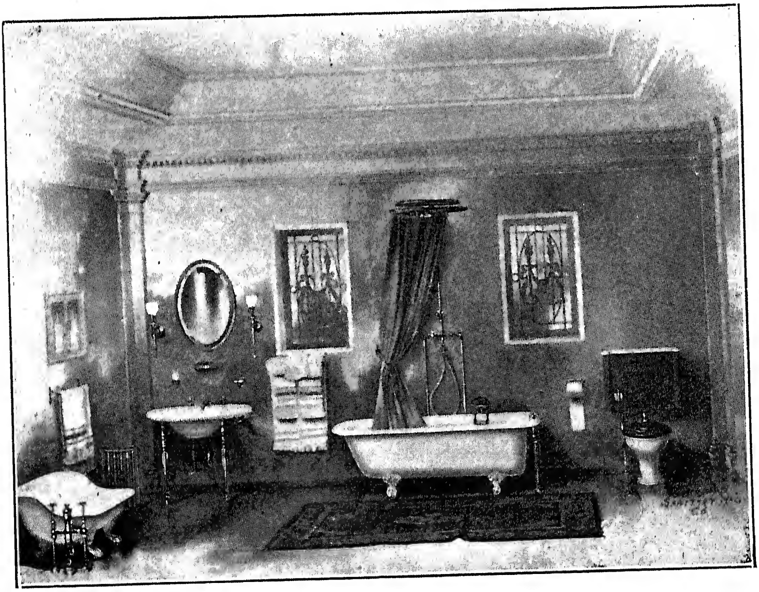


Fig. 125b.

Two Views of Modern Bath Rooms, Taken from Catalogue of Standard Sanitary Mfg. Co., Pittsburgh, Pa.

tub set in the center of the floor. Two alcoves of the room contain a shower and needle bath and a water-closet, respectively.

The special application of the principles of sanitary drainage and sanitation to hospitals, theaters and school buildings is discussed in Chapter VIII as well as in the author's recent book "Sanitation of Public Buildings," while the plumbing of bath houses forms the subject of a chapter in his illustrated work "Modern Baths and Bath Houses."

CHAPTER III.

ADVANCED AND SIMPLIFIED PLUMBING.

Systems of Plumbing. — A critical consideration of the layout of the plumbing and the house drainage to be found in houses at the present day shows that we can distinguish three principal systems, namely:

(*a*) The **antiquated** or defective **system.**

(*b*) The **regular** or **modern system** of plumbing as carried out to-day in most cities having plumbing regulations.

(*c*) The **advanced system,** embodying simplified and improved methods that have suggested themselves in the light of recent experience. The last system is the one advocated by the foremost sanitarians as the system of the future.

Antiquated Plumbing Systems. — To the antiquated system (*a*) belong all the defective arrangements of plumbing or house drainage as we see them described in some of the text-books and as we find them in our inspections of those buildings which are more than twenty-five years old.

Among the chief defects of such systems I mention the square brick channels for house drains, or drains consisting of pipes of too large caliber and very often made of vitrified pipe with faulty grade and alignment, with imperfectly closed joints and other defects. To this class belong also those systems in which the soil pipe is not carried the full size to the roof, but either stops entirely at the highest fixtures in the house or else has a diminutive vent pipe carried through the roof.

In connection with such imperfect layouts we generally find defective pan or valve closets with direct flush from the water service instead of by a cistern supply; we also find the other fixtures of a bath room unprovided with separate traps, their waste pipes being run into the lead trap of the water-closet.

In aggravated cases of this class, the safe waste pipes are directly connected with soil pipes, and sometimes local vents for water-closets

or urinals are so connected, thus forming a direct means of entrance of sewer air into the room. Sometimes the overflow pipe of a bath tub or wash basin is connected with a waste pipe on the wrong side of the trap, and the overflow from the house tank or from the underground cistern is connected either with the soil pipe or with the house drain, sometimes even without the interposition of a trap.

The remedies for the radical defects mentioned are well known and require no further discussion. In a general way, I would say from a large experience with such work, that the best and almost only thing to do to remedy such defects is to rip out the entire plumbing and to provide not only new fixtures but also new house drains, soil and vent pipes.

Modern Plumbing Systems. — The second system (*b*), which is the common or **regular system** constructed in conformity with the majority of plumbing regulations of the present day, is in many ways a vast improvement over the old system. It is the outcome of the experience of the last twenty-five years; yet, as I shall explain later on, it is by no means perfect nor as simple and comprehensive as might be desired. In order to point out the chief features of this system, I give herewith a brief description (see also Chapter I).

Every building is connected separately and directly with the sewer in the street in front of the house, or with the sewer in an alley in the rear. Vitrified stoneware pipes are used for the main outside house sewer to within a distance of generally five feet of the foundation walls; under special conditions outside sewer pipes of iron are used.

The diameter of the house sewer is made much smaller than formerly. In the case of country houses where the rain water is excluded, and also in the case of urban residences, in cities having the separate system of sewerage, its diameter is determined by the number of plumbing fixtures. Where, however, the rainfall is discharged through the house sewer into the public sewer, the size of the house roof, the area of the lot, if paved, and the amount of rainfall govern the size. Speaking generally, small houses are readily drained by four-inch sewers, five-inch sewers answer for large city

houses, and six-inch sewers are required only for very large buildings. For buildings covering a wide area it is better to provide two or more six-inch sewers rather than to use one sewer of extra large size which ordinarily runs not more than one-fourth full and hence lacks a scouring flush.

The smaller the size of the pipe, the larger must be the inclination given to the house drain to secure a velocity of flow which will prevent deposits. Where sufficient fall cannot be obtained flushing arrangements are provided. All joints are made absolutely tight to prevent contamination of the soil under and around habitations by the leakage of sewage and to prevent, in the country, the pollution of the drinking-water in wells.

All inside house drainage arrangements are governed by the following three essential principles, viz.: first, all waste matter capable of being transported by water must be removed quickly and completely as soon as produced, and no retention of foul matter in hidden parts must be permitted; second, the air of the house sewer and of soil, drain and waste pipes must not be permitted to enter the rooms of the building through the outlets of fixtures; third, the entire drainage system, including fixtures, traps and pipes, must be self-cleansing and constructed so as to be readily accessible in all its vital parts.

The house drains are, as a rule, carried exposed above the cellar floor. The drain, soil and waste pipes are of heavy cast-iron or else of screw-jointed wrought-iron pipe, and in rare cases of brass. The advantages of the screw joint over the calked joint are the permanent tightness, the reduction in the number of joints, and the greater rigidity of the system. The connections between the house sewer and the vertical soil and waste lines, those with the branches intended for the removal of rain water, etc., and all other junctions are made with Y branches, for right-angled connections impede the flow and create stoppages. Cleaning hand-holes are provided at all traps, bends and junctions. All soil and waste pipes are extended full size through the roof, and the outlets on the roof are left open and unobstructed.

All fixtures are separately trapped and are concentrated in a few groups; this concentration leads to more frequent use of the

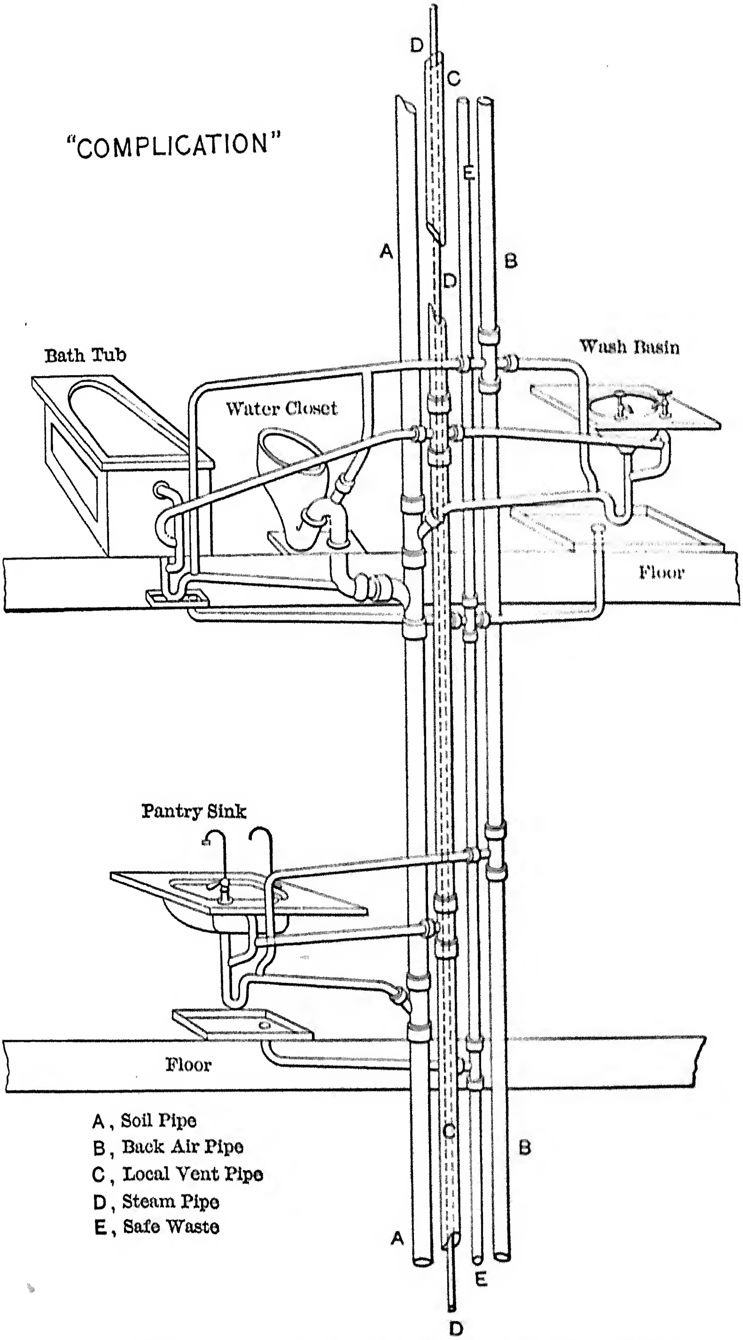


FIG. 126. Modern Plumbing System Showing Complication of Layout.

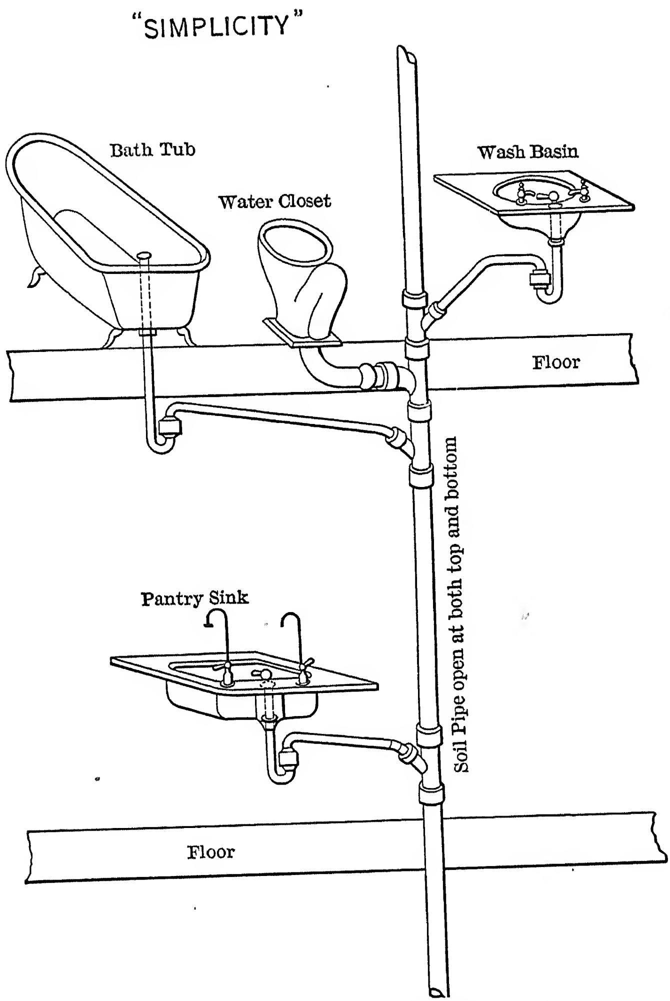


FIG. 127. Advanced Plumbing System Exhibiting Simplicity of Layout.

apparatus, and this in turn secures a more thorough flushing and cleansing, particularly where fixtures are arranged to act like a flush tank. The points enumerated so far are all excellent, and leave scarcely any room for improvement.

Since the S-traps are liable to siphonage, a second system of pipes, called "back-air pipes," is carried parallel to the soil and waste lines, and branches are run from these vertical stacks to the upper bends or crowns of all fixture traps (see Fig. 126). Where there are fixtures above one another on several floors this leads to a double pipe system and to a confusing network of branch pipes. Sometimes a third pipe system, of local vent pipes for fixtures, is used as shown in the illustration, and adds still further "complication" to the work. The modern intricate pipe system of houses has in this way introduced new evils and new dangers, some of which will be alluded to further on.

Advanced Plumbing System.—The **advanced system** (*c*) of plumbing has up to the present time been installed in only comparatively few cases. It is distinguished from the regular or "double pipe" system chiefly by reason of its **greater simplicity and compactness** (see Fig. 127). The principles of house drainage remain much the same, while the advance consists in the simplification of the work, in greater thoroughness of workmanship, and in greater safety. I have for many years contended, and a long experience has only confirmed my views, that where plumbing fixtures are located within a short distance of a well-ventilated soil or waste line, the special back-air pipes can with safety be dispensed with, provided non-siphoning traps are used under basins, bath tubs and sinks, and provided types of water-closets are used which have a deep waterseal.

Able sanitarians have at various times explained the advantages of the system and demonstrated that it is safer and more scientific than the complicated double-pipe system. In my own practice I use it by preference wherever I am left untrammeled by the dictates of Building or Health Department regulations. Figure 1, Chapter I, illustrates a system of house drainage based upon these principles. The illustrations, Figs. 213 and 214, in Appendix B, are also intended to explain the difference between the "double-pipe" and the "single-pipe" systems.

Trap Ventilation. — The **advocates of back-airing** claim that separate vent pipes are necessary —

1. To prevent traps from being forced by siphonage or back pressure, also to prevent the absorption of gases by the water seal.

2. To aërate the traps and every inch of the branch waste pipe.

The first object can be accomplished safely by methods which are less costly and less complicated, and the second is attained at each discharge of a plumbing fixture provided this is used constantly, and also provided it is constructed so as to be quick-emptying, and its discharge working similarly to that of a flush tank.

Objections to Trap Venting. — Some of the reasons why the **back-airing of traps should be given up** are as follows:

1. Trap vent pipes increase the liability of the seal of S-traps being destroyed by evaporation. While an unvented non-siphoning trap may hold its seal for about two months, a back-aired common S-trap loses it, according to experiments, in from four to twelve days.

2. The system of back-venting renders possible the making of dangerous by-passes by the blundering of careless or incompetent mechanics.

3. The use of trap vent pipes increases the amount of piping and the number of pipe joints in a house, and in this way the danger of leaks is greatly increased. In any case they cause greater complication without corresponding greater security.

4. Incidentally, trap vent pipes increase the cost of plumbing and the money paid for them to plumbers is spent quite uselessly. A calculation undertaken by a careful investigator showed that the amount of piping is increased by 33 per cent and the number of pipe joints by 66 per cent. The total cost of a plumbing job is increased by at least 10 per cent and often even more.

5. Back-air pipes are liable to stop up at the crown or upper bend of the trap from congealed grease or other semi-solid matter. In Cologne, Germany, all back-air pipes which an investigating

committee had cut open were found choked with either grease or coffee grounds or cobwebs. In St. Paul, Minn., an examination by a plumbing inspector showed that out of a total of 23 houses, 12 houses had the vent pipes from kitchen sink traps completely stopped up by congealed grease and particles of vegetable matter, or by lint from kitchen towels. Of the 11 others, only one house had a sink vent pipe which was perfectly clear and unobstructed, and this was found to be due to the fact that hot water and lye were used once a month in the pipes. In 7 out of the 11 houses a soft slimy substance was found adhering to the interior of the vent pipes for two or three inches above the crown of the trap, and in the other three the vents were partially stopped up. The vent from the S-trap under the kitchen sink in my own house has been found partially stopped up five times in ten years, and would doubtless have become entirely stopped up before the end of this period if I did not have it cleaned once a year. In northern latitudes, where soil and vent pipes above the roof may become closed by frost, traps will readily be siphoned under such conditions.

6. The trap vent pipe, if placed much below the trap seal, does not protect the pipe against self-siphonage or loss of seal by momentum. This is a point to which very little attention has been paid.

7. Non-siphoning traps with more than the ordinary depth of seal are particularly desirable where the mouth of the soil pipe and through it the seal of traps is exposed to the action of boisterous winds, as for instance near the top of buildings, the winds causing an agitation in the trap water by which the ordinary S-trap loses its seal by degrees.

Mr. Putman, a well-known architect of Boston, who has given a great deal of attention to sanitary drainage, calls the trap-vent law "one of the most unfortunate and burdensome building laws ever inflicted upon the people, and an imposition upon the public."

The late Colonel Waring stated that in his judgment "the separate ventilation of traps, where the main soil pipe is at least four inches in diameter, and open at the top and bottom, is unnecessary. . . . Continued experience and observation tend more and more to confirm the opinion that the back-venting of traps, aside

from its great cost, does more harm than good, that is to say, that a trap is more likely to lose its seal if it is back-vented than if it is not."

An English expert on drainage called "a diagram of house plumbing, protected by ventilation pipes as prescribed by most American authorities, a bewildering nightmare of complicated ingenuity" (see Fig. 126), to which statement many advanced sanitarians will doubtless heartily assent.

The fact is, S-traps with vents are perfectly safe only *if* the vent pipes are of sufficient area, *if* they are not of too great length, *if* there are no sudden bends and not too many of them, *if* they are free and unobstructed and if their fixtures are used every day. The conclusion is therefore inevitable that, as ordinarily arranged, vent pipes are "useless complications."

Comparison of Methods.—A comparison between the two methods may be found in Chapter XII of my book "Sanitary Engineering of Buildings" N. Y., 1899. In my judgment the improved and simplified system shown in Fig. 127 and also in Fig. 214, Appendix B, is far superior to the one commonly required by rules and regulations. It is admitted by many who have taken up this question without prejudice or bias that the present tendency in plumbing work is towards an undue complication of the work. It would seem to me, therefore, that the points of superiority of the simpler systems should be emphasized at all proper opportunities and that a plea should be made for the revision of municipal plumbing regulations.

To the health officers of those towns or cities which are about to make plumbing regulations I suggest that the better way would be to make it optional with the architect or owner of a building whether he will choose the common or regular system with double piping and incur an unnecessary expense, or use the advanced, improved, simplified and safer method.

One-pipe System and Non-siphoning Traps.—I am more than ever convinced that the **one-pipe system,** as I have sometimes called it, is the coming system and that within the next few years the rules and regulations of our larger cities will be amended accordingly. In my judgment a plumbing regulation requiring the use of traps

with anti-siphoning properties and with a considerable depth of seal would tend to secure much safer and better work than the majority of the present rules. For houses in smaller cities and in thriving rural communities I can, without the slightest hesitation, advise the adoption of the advanced plumbing system on account of its greater simplicity, safety and economy.

The following **personal experience** is here inserted as a case in point.

Experiences of an Expert. — Some years ago the writer was called upon to prepare the plumbing plans and specifications for a new house which a client was erecting in the suburbs of New York. It was the intention of the owner to secure first-class work in every respect, and the plumbing was laid out with this object in view. The writer had full charge of the work during its construction and superintended it from the start to the finish.

He entertained the conviction, even at that early period, that the "back-airing" of traps was an unnecessary requirement and that the plumbing system of a house could be arranged in a much safer, less complicated and incidentally less expensive manner, by omitting the back-airing from the crown of the traps and using instead non-siphoning traps; by placing all the fixtures within a short distance of a fully ventilated main soil pipe, and by using in the case of water-closets fixtures of such type as to hold a large depth of seal.

Some years later the owner desired to make an addition to his plumbing work by installing a new bath room on the third floor. When the house was erected the town had no plumbing regulations, and it was then a matter of much satisfaction to the writer to be able to carry out what he considered then, and has considered ever since, an *advanced system* of plumbing. Conditions had somewhat changed since then. The town, which is situated in New Jersey, at a distance less than fifty miles from the New York City Hall, had become a city; a Board of Health had been created, and among the duties of the board was the inspection of all new plumbing as well as of additions to existing systems. The newly created city issued a set of plumbing regulations modeled largely after those of New York, and the rules of the board required the filing of plans and the approval of the work, as shown on them, before it could be carried out.

The work for the new bath room was duly let to a responsible New York plumber, and the writer, fully desirous of complying with the regulations, sent a set of plans showing the addition to the plumbing work to be filed at the office of the Board of Health. Right here is where he met his first experience. He sent his assistant out on the train,

and when he came to the city he inquired for the office of the Board of Health to file these plans. He was told that there was no office at which plans could be filed, and that he would have to leave them either at the house of the secretary of the Board of Health (a veterinary surgeon) or else at the house of the plumbing inspector, who was a journeyman plumber, employed during the day by some local plumbing firm. After fruitless efforts to find either one of the parties named, the assistant returned to the city with the plans which he had been unable to file. A second effort made personally by the writer proved almost as futile. Renewed search in the City Hall of said city failed to find any office where plumbing plans could be filed. A call on the president of the Board of Health secured the information that the plans would have to be filed at the secretary's office. An inquiry at said office showed that the secretary was ten miles away attending to a sick horse.

The plumbing regulations of the new city required either the back-airing of the traps or the substitution of some approved mechanical device for the prevention of siphonage.

In Fig. 128 is shown the old work in the bath room on the second floor, which consisted of a Dececo water-closet with deep seal and with unvented trap; of a bath tub with a non-siphoning trap and of a slop-sink with an ordinary S-trap, which had a vent which entered the soil pipe above the then highest fixture on the second floor.

In Fig. 129 the proposed new fixtures on the third floor are shown without vent pipes, it being the intention to use a siphon-jet closet near the soil pipes, and non-siphoning "Hydric" traps under the bath tub and wash basin, each of which was within four feet of a vented soil-pipe line. Special application was made to the Board of Health to permit, in accordance with their rules, the use of the McClellan anti-siphon vent attachment to render the trap of the slop-sink safe against siphonage by discharge from the new fixtures on the third floor.

The application to pass the work as proposed was denied, although no reasons whatever were given for the denial. The Board of Health and its plumbing inspector insisted upon a two-inch vent pipe being carried up from the slop-sink to the third floor and above the highest fixture, to terminate in the soil pipe. The application for the use of non-siphoning traps on the wash basin and bath tub on the third floor was also denied, but the omission of the back-air pipe on the third-floor water-closet was granted.

The entire work was, therefore, carried out as per Fig. 130. When the work was well under way, the plumbing inspector of said city informed the contractor doing the work that he would require a second vent pipe to be carried up to back-air the old Dececo water-closet on the second floor. This would have required a very expensive alteration to the owner, inasmuch as the bath-room floor was tiled, and would have to

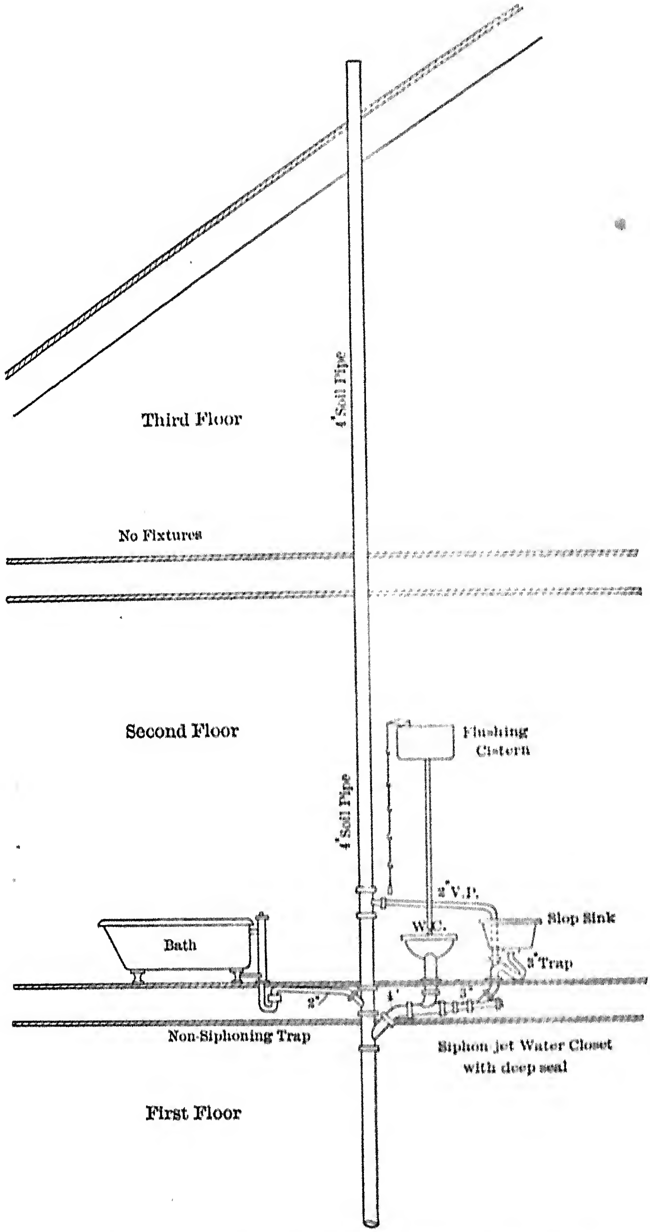


FIG. 128. Section of House Showing Original Arrangement of Plumbing.

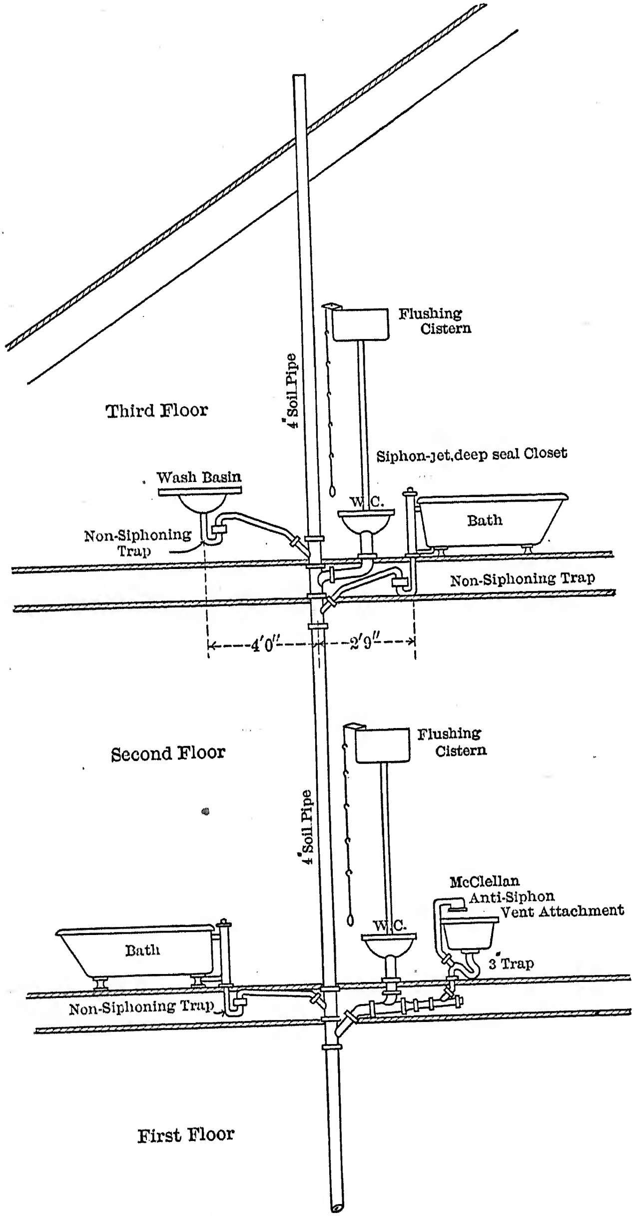


FIG. 129. Section of House Showing Arrangement of Plumbing as Proposed.

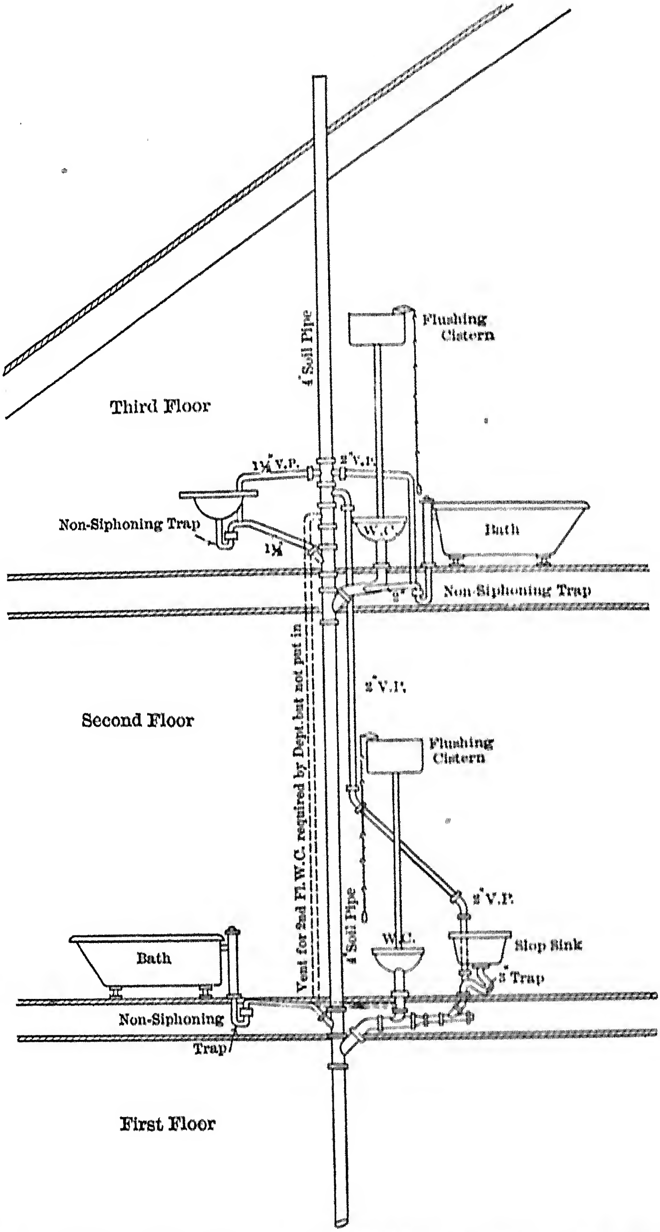


Fig. 130. Section of House Showing Arrangement of Plumbing as Carried Out.

be cut in order to apply a vent pipe at the lead bend of said closet. The writer could not see any necessity whatever for such a proceeding, and this for a great many reasons, of which only two will be stated, namely:

First. The two-inch vent pipe applied to the slop-sink on the second floor, as a matter of fact, also vented the Dececo water-closet trap.

Second. Not even in cities where the most rigid plumbing laws are carried out can a law be made retroactive so as to apply to work done many years ago, and particularly not so when said work has proved to be of the most efficient and safest character.

The writer therefore instructed the contractor to disregard the requirements of the plumbing inspector and not to touch the second-floor water-closet fixture. This, however, was not satisfactory to the Board of Health and its inspector, and it was suggested by them to the writer that an amicable settlement of the difficulty might be arrived at by submitting the question to a third party. They named an inspector of a neighboring city where back-airing was carried out the same as in New York and Boston. Naturally the writer objected to such a choice of the third party as arbiter in this question, one of the reasons given being that the man proposed was not an acknowledged expert or authority in these matters, however good and efficient a plumbing inspector he might be. Instead the writer suggested that he would be willing to have the question at issue arbitrated by either Mr. J. P. Putman or Mr. William Atkinson, or by members of the firm of Waring, Chapman & Farquhar, or by plumbing inspectors of a small town where the plumbing rules had been framed so as to permit the use of non-siphoning traps in certain cases where back-airing seemed to be absolutely unnecessary.

This counter-proposition of the writer, as might have been expected, was also not accepted, but a joint meeting was held at the house in question. It so happened that on the opposite side of the house from where the plumbing alteration was being executed there were two bath rooms, one on the second and one on the third floor, both arranged with non-siphoning traps and the use of deep-seal water-closets. After thoroughly discussing the question of back-airing, the members of the Board of Health and the plumbing inspector were invited to watch the seal of the second-floor water-closet while the third-floor water-closet was discharged together with an adjoining bath tub. To the utter astonishment of the gentlemen the trap seal on the second-floor water-closet did not move at all, proving absolutely that the danger from siphonage was only fancied and imaginary and not at all actually present.

Fortunately for the owner, this settled the question first raised, whether the second-floor water-closet on the opposite side of the house should have the additional vent pipe. The Board of Health and its plumbing inspector receded from their position, and when the work was actually completed the writer made tests on that side of the house, and found that

a repeated discharge of the new water-closet on the third floor and the adjoining bath tub did not produce any siphonage in the second-floor water-closet, even under the most adverse condition, namely, the soil-pipe mouth on the roof kept closed during the test.

The lesson of this case is obvious: it proves beyond a doubt that a good deal of the back-airing required by plumbing inspectors, by Boards of Health or by Building Departments is entirely unnecessary and a heavy drain on the pocketbook of house owners.

CHAPTER IV.

PLUMBING IN ITS RELATION TO DISEASE AND MUNICIPAL CONTROL OF PLUMBING.

Dangers of Defective Plumbing.— The professional and trade papers of the last twenty years have been so filled with accounts of the **dangers of defective plumbing,** the daily press has so many times called attention to the "deadly effects of sewer gas" and the cry has been so often raised, "Look to your drains," that we have become accustomed to think of the plumbing and drainage of houses as being the chief causes of many of the grave ills to which human beings are subject.

Recent Progress in General Sanitation.— Careful observers, however, know that a great many other conditions affect the well- or ill-being of the human race. While it is doubtless true that a **lower death rate** may in some cases follow after improvements in the drainage and plumbing of habitations, it is impossible to tell just how much of it is actually and solely due to higher standards in plumbing, for there have been in the past fifty years an **enormous advance** and a **steady progress** in the **general sanitation** of **towns** and **dwellings.** This progress was slow at first, but it has been constantly going on, so that to-day the effects of improved sanitation are felt in every section of our country. **Modern sanitation,** however, comprises much more than merely correct plumbing methods and efficient sewerage, for it includes also a better and purer water supply, more efficient ventilation, better conditions of foods and clothing, cleaner streets, improved methods of housing our populations, increased public bathing facilities for the poorer classes, sanitation in school buildings and other public institutions, and many other factors.

Causes of Preventable Diseases.— It is conceded that criminally defective house sewerage and plumbing work have, in some instances, been found to exist where cases of zymotic disease occurred, yet the writer has encountered in his professional practice a number of

cases where such illness was proven beyond a doubt to have been caused by other factors. Some of these cases occurred where the plumbing and drainage upon inspection were found to be entirely in a safe condition; in other cases, though the inspection or the test did show some defects, the outbreak of an epidemic could be traced conclusively to other causes. By personal observations I have thus slowly and by degrees only acquired the conviction that a great deal of the sensational writing or talking on defective plumbing or drainage is ill-advised, indeed that it is apt to mislead the layman and the general public. In my judgment a great deal of harm has been done in the past by unsubstantiated reports on the alleged effects of bad drainage or bad plumbing.

Sewer Gas Theory not Upheld by Sanitarians.—If space permitted, I would quote at length the opinions and views of some of the best medical observers of Germany and other countries, whose conclusion is that **there is no positive proof of any direct connection between bad drainage or bad plumbing and diseases** such as diphtheria, cholera, etc. From a mass of professional testimony on record I shall quote only a few important points.

The modern German sanitarians are nearly united in being opposed to the so-called "sewer-gas theory"; they claim that the researches of von Pettenkofer, of Pasteur, of Dr. Koch and others have established almost beyond a doubt the fact that every infectious or zymotic disease requires the presence of a specific micro-organism or pathogenic bacterium to cause it, and that the gases of putrefaction *per se* cannot cause the disease. Moreover, it is claimed that pathogenic bacteria, cast off from diseased persons (either with the fæces, urine, the sputa or skin particles in ablutions) do not find in the house drains and street sewers conditions favorable to their growth. As a rule, owing to absence of oxygen, or owing to the existence of non-pathogenic bacteria the germs of disease are crowded out, as it were, and die, while the few which may survive are said to lose their power for harm. In the sewers they attach themselves to the damp sides of their interior and rise but seldom or not all at, into the air. This may also be an explanation why the bacteriological examinations of the air of sewers show that it contains comparatively few bacteria. German sanitarians accordingly argue that **sewer air per se does not cause specific diseases.**

This view about the harmlessness of sewer air has been held abroad for some years, and I have myself inclined to it for some time, and it has quite recently been confirmed by the results of experiments made by Prof. C.-E. A. Winslow, of the Massachusetts Institute of Technology, in Boston.

Prof. A. Jacobi, a very high authority of New York City, in a paper on "The Production of Diseases by Sewer Air," comes to the conclusion that "foul air and sewer gas do not create diphtheria, but they do create such a condition of general ill-health as to afford the diphtheritic virus a ready resting-place." He argues that "there is no connection (in New York City) between diphtheria and sewer air in any shape or form," and cites the experience of the New York Health Department that "both diphtheria and typhoid have occurred where plumbing was perfect, and were often not found where it was defective."

On the other hand, I have always held the view, and believe now, that no matter whether any connection between bad drainage and disease exists or not, it is absolutely essential that the drainage and plumbing work of habitations should be *correctly* arranged. If there is one method of doing a thing right and another one by which it is done less well, the *right* method only should be chosen.

Why Drainage and Plumbing should be Correctly Arranged.— We require correctly planned drainage and plumbing arrangements for several important reasons, viz.: we must prevent the air of soil pipes and drains from becoming putrid; we must also prevent any escape of noxious air into the interior of a house; all foul smells are unpleasant and if inhaled for any length of time they may have a deteriorating influence upon health. *Accumulations or escapes of foul gases* cause general sickness, various ailments, or sore throats; they also reduce vitality and *predispose to sickness* and so *assist indirectly in the dissemination of diseases.*

The air of modern street sewers is always much diluted, and even the house pipes are nowadays so well ventilated that no great accumulation of gases can exist in them. Therefore the danger becomes very much reduced where good planning, construction and maintenance of street sewers and house drains are enforced. By following the essential requirements of good drainage, viz., good construction, ventilation, flushing, tightness of joints, safe

trapping, etc., we diminish greatly the chance of any harm arising from sewer air.

Plumbing Rules and Regulations.—In the past, correct principles of house drainage have not often been followed, and even twenty-five years ago the plumbing in houses was done in so crude and unscientific a manner that it became necessary to subject this work of the craftsman to **official rules, regulations or ordinances** and to the **inspection** of special municipal officers called plumbing inspectors.

Municipal Inspection of Plumbing.—In the United States the municipal **inspection of plumbing work** was instituted about the year 1881, and among the first large cities to have an official inspection system were Washington, New York and Boston. There are now a great many other cities, large as well as small, which have followed in this matter. In all instances the plumbing rules were made a part of the health ordinances, and out of the various municipal departments it was the Department of Health which was intrusted with the carrying out of these rules and with the inspection of all new plumbing work. Later on, in some of these cities, notably in New York and Brooklyn, and I believe also in Boston, the plumbing inspection was transferred from the Health to the Building Department.

Should the Health or the Building Department Control the Plumbing and Drainage?—The question here arises: To which of the municipal departments should this subject be assigned? One of the reasons why in New York City the filing of plumbing plans and specifications and the plumbing inspection were transferred from the Health to the Building Department was that, inasmuch as the Building Department had control over the erection of buildings, it should also have control over the plumbing work in them; that, inasmuch as the architects or builders had to file plans for construction, their work would be simplified and the labor of the municipal officers reduced if the system of plumbing was shown on the construction plans.

This argument, however, soon proved itself to be fallacious, for in practice one plan, to cover not only all the points of construction but also the plumbing, proved to be so complicated as to be a greater burden to the examining inspector, as well as a source of more trouble to the architect who had to prepare it.

There seems to me to be no more reason for placing the plumbing of a building under control of a Building Department than to subject other matters of interior construction to such a control, for instance, the steam and ventilating work, the gas-piping and the electric-wiring work. If defective plumbing work may cause ill-health or disease, then it would seem to me that **the Department of Health is the proper body** under whose control this subject should be placed.

Plumbing under Jurisdiction of the Health Department.— It is therefore my judgment that wherever cities or towns adopt a system of official plumbing inspection — and I am a firm believer in the advantages derivable from such a system — it should be the Health, and not the Building, Department under whose control the plumbing and drainage should be; but if for some reason or other this cannot be done, then I should be in favor of placing the plumbing and drainage of houses under the control either of the city engineer in small towns, or of the Municipal Department in charge of the construction or maintenance of the city sewerage system.

Dr. Charles V. Chapin, Superintendent of Health of Providence, R. I., in his book "Municipal Sanitation in the United States," gives the following list of cities, in which plumbing is controlled by municipal departments other than the Board of Health.

In New York City,	Department of Buildings.
In Boston,	Department of Buildings.
In Milwaukee,	City Engineer's Department.
In Cambridge,	Superintendent of Buildings.
In Cincinnati,	Inspector of Buildings.
In St. Louis,	Board of Public Improvements.
In Somerville, Mass.,	Inspector of Buildings.
In Butte, Mont.,	Inspector of Buildings.
In Newton, Mass.,	Inspector of Buildings.
In New London,	Board of Sewer Commissioners.
In Erie, Pa.,	Water Department.
In Providence, R. I.,	Independent Department.
In Omaha,	Independent Department.
In Pawtucket,	Independent Department.
In Memphis,	Independent Department.
In Columbus, O.,	Department of Public Improvements.
In Minneapolis, Minn.,	Building Department.

Bureaus of Plumbing Inspection. — Let us assume, then, that it is agreed that the official inspection of plumbing and drainage of buildings is desirable in order to prevent bad work and its possible ill results, and let us take it for granted, further, that it should be placed under the supervision of the officials of the Health Department. When such department deems it necessary or desirable to have official plumbing regulations, it should proceed on a business basis, it should establish a regular office or **bureau of plumbing** and should place it in charge of salaried officials. If, for any reason, the municipal budget should be unable to make the proper and necessary allowance for the employment of examining clerks and plumbing inspectors, then it would be better not to have any system of municipal inspection.

I know of a large city of about 100,000 inhabitants, not many miles from New York, which has a plumbing department and also plumbing inspection, and the two duly appointed plumbing inspectors are both master plumbers doing a thriving business in their town, and the plumbing work which Mr. Brown does is officially inspected and his plans approved by his colleague Mr. Smith, and vice versa. That would hardly seem to be a fair method of securing good results, particularly if Mr. Brown and Mr Smith happen to be on good terms and intent upon keeping all outsiders away. In another suburban community in the State of New Jersey which recently became incorporated as a city, the Board of Health issued plumbing rules and required the filing of plumbing plans, but no office was provided for to receive such plans, and the plumbing inspector was a journeyman plumber, occupied during most of his time on work of some local firm.

Plumbing Inspectors.— All health officers in charge of plumbing regulations or plumbing inspections should have a thorough practical knowledge of the subject. The **plumbing inspectors** appointed by them and working under their direction should be well qualified for their position: they should be required to prove their qualification by an **examination in sanitary science,** and also show their fitness for the practical part of the work. Fitness for the discharge of the duties of the office should be the only guide in such appointments and not political motives or "pull," or the affiliation of such persons with the ruling political power or party. The inspectors should be subject to civil-service examination and civil-service rules, and their appointment should continue during good behavior.

They should not be subject to removal when another political party comes into power.

I freely confess that I have never been in sympathy with the idea, which unfortunately seems to be the ruling one in many cities of the United States, that "to the victors belong the spoils." If any good to the public, to the tax-payers, to the house builders, is to come from an official plumbing inspection, I hold that it is absolutely "immaterial and irrelevant" whether the inspector of plumbing is a republican, a democrat, or possibly a "mugwump." As some one has truly said, "Degrading political influences should never be permitted to impair the efficiency of a well-organized Health Department."

. . . .

Plumbing Regulations.— During the past ten years I have collected and filed a large number of official **plumbing rules and regulations** from cities and towns in all parts of the country, and I had many opportunities of examining these very closely. I have also in a great many cases been professionally consulted as to the best rules to adopt, and I have advised many public officials on the different sections composing such plumbing rules.

It has been my experience that some of the best rules came from the smaller towns. Their rules had been drawn up carefully after a good deal of study and consultation, either by practical men in the trade, or by municipal engineers who had made a special study of plumbing and drainage. I find that in a great many other cases the plumbing rules and regulations of cities have been copied almost entirely from the existing rules of the larger cities like New York or Boston, and in this way some serious errors and imperfections in these rules have time and again been copied and perpetuated.

Plumbing rules should be as **concise, comprehensive** and **brief** as possible.. Each section should be definite and should not leave room for doubt as to what its intention is. It would seem to me that in the case of the smaller towns a simple and comprehensive set of rules drawn up from original investigation would answer a great deal better than the very extensive and long rules of some of our metropolitan cities.

Whatever the rules on plumbing issued by the Health Department may be, it seems to me that they should be so framed as not to allow of *arbitrary* interpretation on the part of the plumbing inspectors, as is so frequently the case.

Defects in Plumbing Regulations.— I have already had occasion to state that, in my judgment, even the most elaborate of plumbing rules are open to criticism in many respects. It seems appropriate to point out in this chapter at least a few of the rules which, to my way of thinking, contain disputed matters.

Main House Trap.— There is, first, the question whether or not the **main house sewer** should have a **trap** near the front wall of the house. It must be conceded that where the house pipes are known to be absolutely tight and are provided with plenty of ventilation to the roof, it would be better to omit the trap. This secures at least two advantages, namely, it does away with the tendency to stoppage in the trap and it also offers the best possible solution of the difficult problem of how to ventilate the street sewer. It is of course necessary that the latter should be well planned, well constructed, well flushed and well cared for.

When a trap is used on a house sewer — and it does seem to be necessary in the case of foul street sewers or in the case of connections with cesspools — it becomes necessary to provide a **fresh-air pipe,** which should enter the house sewer above the main trap and which is intended to establish a circulation of air throughout the entire house pipe system. The difficulty with the fresh-air inlet lies in choosing a proper location for it. This difficulty exists only in cases of city buildings, for in country towns and villages, and for isolated country houses, it is comparatively easy to select and provide a secluded place for the fresh-air inlet at a sufficient distance from the house. In our cities we have for years been struggling with a sort of brick pit or basin placed near the curb, covered with grating in which the fresh-air pipe terminated (see Fig. 200, Chapter I). Practical experience demonstrated the utter failure of this device, and we have by no means found an efficient substitute for it. In New York City, for instance, every house owner, who builds or alters a house, was for some time compelled by the Building Department to use a new patented device which was not only very expensive but quite worthless.

Types of Water-closets Approved.— Regarding the **types of water-closets** which are permissible in buildings, I am by no means in entire accord with the plumbing regulations of most cities. In New York, for instance, enameled iron water-closets are absolutely

prohibited by the rules, and yet I cannot imagine of anything better, stronger or more adapted for factories, stables, railroad stations, schools, insane asylums, etc., than a good, well-made iron flushing-rim or siphon-jet closet, in which the entire inside is well covered with porcelain white enamel.

Again, these rules prohibit the use of the so-called "long flushing-rim hoppers," except in situations where a closet bowl holding water would be exposed to freezing. As a matter of fact I have had under personal observation for a great many years one of the best types of long flushing-rim hoppers, and I must frankly say that, notwithstanding the fact that it lacks the advantage of a large volume of water in the bowl, it is to my mind one of the *best* closets of the present day. Of course it should be well used and it should have a well-regulated and plentiful flush.

Use of Automatic Flush Tanks.— The rules of many cities prohibit the **use of automatic flushing-cisterns for urinals** and require instead a flushing-tank with a chain-and-pull device. We all know the great carelessness exhibited in the use of such fixtures and the negligence of the general public in flushing them after use, where the fixture is provided with a stop cock and a water-supply pipe. While the rule appears to be proper in cases where it is desired to limit the use of water or to stop reckless waste, I cannot see why an owner of an office building, for instance, who puts in a water meter on his service and is willing to pay the water bill in full, no matter how large it may be, can be lawfully prevented from using such automatic flushing-tanks.

Trapping of Fixtures.— Nearly all rules call for a **separate trap under each plumbing fixture,** to be placed as close to the outlet of the fixture as possible, and yet in the case of a set of three or more washtubs Building Departments have been known to object to a layout of the plumbing in which each of the tubs had a separate trap, which according to my experience is the best possible arrangement of such work.

Again, in the bathrooms of private houses, where there is a shower or needle bath alongside of the wash basin and no bath tub in the room, which certainly can mean but one thing, and that is that the occupant of said house or bathroom intends using the shower bath instead of a bath tub probably as frequently as if he had a tub,

plans with such arrangement of fixtures have been rejected by the Municipal Building Department of New York City, because each of the fixtures, namely the basin and the shower bath, had a separate trap. Instead of this arrangement the department required that the waste from the basin be run into the trap of the shower bath "in order to keep it supplied with water," yet by so doing a channel or waste pipe, sometimes 8 or 10 feet in length and lined with slimy waste matters, was left untrapped and in full connection with the air of the room.

Use of Wrought-iron Pipe for Soil and Waste Pipe.—Where the rules permit the **use of wrought iron for soil and waste pipes,** they require such pipe to be galvanized and exclude the use of asphalted wrought-iron pipe, whereas, as a matter of fact, the asphalted pipe is much smoother on the inside than the common galvanized pipe; and asphalting, properly done, is probably a better protection against rust than the common method of galvanizing. I have seen some rules which permit the horizontal portion of the house drain to be asphalted wrought-iron pipe, but insist upon the soil pipes being galvanized. It would be interesting to know the why and wherefore of such rules.

Again, where wrought-iron screw-jointed systems are permitted, the rules require recessed drainage fittings for the soil and waste pipes, but permit the use of ordinary steam fittings for the vent pipes. It must be evident that, if the recessed fitting has any value at all, it is just as desirable to use it for the vent pipes and particularly for the horizontal runs of the same.

Separate Connection of Houses with Street Sewer.—The rules of most cities call for every building to have its **sewer connection** directly in front of the building. I well remember a case of this kind where there was no sewer in the avenue in front of the building, but in a private alley in the rear a private sewer had been laid by the owners abutting on said alley. When I filed my plans in the department showing the house sewer to run to the rear to said private sewer, instead of to the front, where there was no sewer, my plans were promptly disapproved, and it required several hours' arguing, on different days, to convince the head of the department that the sewer connection in the rear was just as good and certainly just as permissible as the plan requiring the additional

outlay of money, to which he wanted to subject the owner of the property by compelling him to build a private sewer in front of the house.

Inclination of House Drains and Waste Pipes.— Other points in plumbing rules, which were well meant when they were drawn, have been unfortunately misunderstood and misinterpreted. Take, for instance, the rule requiring that every house sewer should be laid with an inclination of at least $\frac{1}{4}''$ to the foot. This rule was intended to establish a **minimum fall,** and it is quite obvious to anyone who has at all studied hydraulics, that the smaller the diameter of the pipe the greater its inclination should be; yet by common consent the majority of mechanics call this "$\frac{1}{4}''$ to the foot" the standard fall, simply because it is the minimum fall allowed by the department, and I have in my work the greatest difficulty in securing the laying of the pipes at a larger fall where I think this would be desirable, the mechanics contending that the pipes have been laid at the *standard* $\frac{1}{4}$-inch fall.

Back-venting from the Crown of the Trap.— The rule which we find in nearly every plumbing regulation, requiring the **back-venting of pipes,** namely, that "branch vent pipes should be connected as near to the crown of the trap as possible," is one which it would be well to omit entirely in the future, for it is not followed in the case of earthen water-closets and earthen slop-sinks. Similarly in the case of basin and sink traps it is very seldom nowadays that one finds the branch vent applied to the crown of the trap, one reason being that this would require a coupling or washer joint at the back-vent connection, which experience has shown to be unsafe. Therefore screw connections are prescribed by the rules, and, while this manner of connection is all right, it does away with the branch-venting of the crown of the trap, and substitutes for it the better system of continuous wastes and vents. Therefore the above-quoted rule should be abolished.

Extension of Pipes above the Roof.— The intersection of the line of vent stacks into the adjoining soil or waste pipe above the highest fixture is now permitted by the majority of rules, and in New York City the only exception is "where there are fixtures on more than six floors." The reason for this exception is somewhat obscure, and it would be decidedly more advantageous to carry *all* vent

pipes separately through the roof, even if this should require additional holes to be cut through the roof. Wherever the pipes are so arranged, it is possible to make a successful peppermint test by pouring the peppermint into the soil or waste line; but, where the vent intersects the other line below the roof, the peppermint test is in many cases a delusion and a snare, because some of the oil may follow through the vent into the bend of the trap and thus the odor of the oil may come out into the room, apparently indicating a leak when really there is none.

Disconnected Plumbing System.—I have on some occasions found it necessary to **disconnect** certain fixtures, for instance, wash basins in the center of a house or in sleeping apartments, or else sinks in operating-rooms of hospitals, from the soil- or waste-pipe system of the house. Where such a **disconnection** is **properly arranged,** it **forms,** in my judgment, a **perfectly safe and sanitary system,** yet it seems almost impossible to get systems so arranged passed under the present rules of many departments.

Open Plumbing Work.—An instance of how even a good rule may fail to work properly is the following: All plumbing regulations at present call for entirely **open plumbing work,** and for the tenement houses in particular the requirement is made in New York City that sinks "shall be left entirely open and the waste pipe and trap of said sinks are required to be of *lead.*" Now I am assuredly, as much as anybody, in favor of open-plumbing work, having advocated its introduction twenty-five years ago, but in the case of tenement houses this rule is, from a practical point of view, a great mistake. The tenants of such quarters have at best a very limited space available, and it is natural for them to use every inch of space, even under the kitchen sink or washtub. They will store the coal scuttle or pails under the sink, and in a very short time the lead waste and lead trap are found dented or knocked flat, and the stoppage of the waste is the inevitable result. Therefore, if the plumbing *must* be open, the rule should call for either brass or iron traps and waste pipes, and it should prohibit the use of lead pipes and traps.

Testing of Plumbing Work.—The **testing of plumbing work** has been one of the chief means of improving the character of such work. I cannot lay too much stress upon the importance of having

the entire work, which is made subject to Health Department supervision, inspected and tested at the various stages of the work. Such inspection and test should be carried out with great thoroughness and faithfulness. One cannot be too particular about the testing of the work. The plumbing rules should state, in a direct and positive manner, how many and what tests the department requires. The kind of test should in no case be left optional with the plumbing inspector.

Water-pressure Test.—For the drain-, soil-, waste- and vent-pipe system, including the branches to the fixtures, there is no better test than the **hydrostatic-pressure test,** which consists in filling the pipes with water; and this test is certainly much superior and better adapted to new plumbing work in course of construction than, for instance, the air-pressure test. The only time at which such a water-pressure test may not be practicable is during freezing weather, and the plumbing rules should distinctly state that only in such instances the plumbing inspector may require the substitution of an air-pressure test.

Smoke Test.—In the same way it is acknowledged to-day by experts that the **smoke test** is the best available test for newly completed work, as well as for old work in buildings to be inspected, and that it is superior in many respects to the peppermint test. It is well known that the **peppermint test,** unless applied with a great deal of care and with a thorough understanding of the lay-out of the plumbing system in a building, is apt to be misleading or to give entirely erroneous indications. In fact, in the hands of careless or unscrupulous workmen such a test is a very dangerous one.

In view of these facts I cannot approve of any plumbing rule or ordinance requiring that the final test to be applied to the work may be *either* the smoke test or the peppermint test, at the option of the inspector. A case recently happened in my own practice where I had inserted in my specification the requirement of a smoke test at the completion of the work. In this case the official plumbing rules had been worded so as to make it optional with the plumbing inspector which test should be applied. He accordingly refused to witness the smoke test, stating arbitrarily that he preferred to have a peppermint test applied.

Benefits Resulting to the Public from Plumbing Inspection.—Experience has shown that the control and inspection of plumbing and drainage work by Health Board officials greatly reduces the chances for scamped work and tends to avoid bad layouts, the use of poor materials, and criminal workmanship. The honest and conscientious workmen as well as the public are thereby benefited. If the practical work done by efficient Health Boards were better understood by the public at large, it would also be more appreciated.

Universal appreciation or approval can as yet hardly be expected, for in every community, whether in cities or in the country, persons exist who remain inimical to the efforts made by the health officials to improve the sanitary condition of habitations. But I venture to assert that a greater degree of appreciation of their labors will, in the course of time, be shown by the public wherever health officers and plumbing inspectors perform their work in an honest, fearless and efficient manner.

CHAPTER V.

DOMESTIC WATER SUPPLY.

The Uses of Water.— Next to an ample provision of uncontaminated air for breathing, nothing is so essential to human life as a **supply of pure and wholesome water.**

Cleanliness, comfort and health in a house depend, to a large extent, upon water being available in an ample supply for immediate use. Much trouble and constant labor is involved in houses where the water supply, coming from cisterns or wells, must be lifted by hand, by means of buckets or hand pumps. There is always a tendency, under such conditions, to use as little water as possible, to the great detriment of personal comfort and health.

A **public supply,** introducing pure water into habitations under pressure, must be looked upon not merely as a great convenience, but as a powerful aid in preventing disease. With regard to the plumbing fixtures in particular, a large quantity of water, always available, is a necessity in order to keep the fixtures, traps and waste pipes well flushed and clean, and to maintain the water-seal in traps so as to effectually exclude any noxious air that may be contained in the waste pipes.

A good plumbing system, efficient sewerage, and a copious supply of water are the three essential requirements for dwellings which should always go together; in fact, without the one, the others are always incomplete and will result in failure.

Quality of the Water.— To be fit for use in the household, water should be uncontaminated, and free from the grosser or suspended impurities, and from organic contamination. **Impure water** is frequently the **cause of disease.** Chemically pure water does not exist in Nature, and all water, whether derived from springs, wells, rivers, or lakes, or from rain-water cisterns, contains foreign elements, some in suspension, others in solution, some organic, some inorganic. The organic substances may be either of vegetable or of animal origin. Besides these, water contains minute forms

of plant life and bacteria, so small that they may only be recognized through a powerful microscope. The inorganic matters in solution may be iron, lime, magnesia, chloride of sodium, sulphates and carbonates of lime or magnesia, and sometimes lead and zinc; those in suspension comprise finely divided clay, fine sand and gravel, and iron rust.

A good water should contain only a small quantity of mineral matter, and should be of moderate hardness, while organic matter in it is always objectionable. Water should be clear and free from turbidity; it should not be discolored, nor should it have any objectionable taste or odor; lastly, it should be moderately cool. Where the water is supplied from a municipal or private water-works system, the individual householder has, of course, no control over the quality of the water, but, in cases where the water supplied is impure, much may be done by the individual to improve the supply by means of household filtration.

Quantity of Water Required.—The **quantity of water** consumed in a household in twenty-four hours depends not only upon the number of its inhabitants, but also upon the size and character of the house, the number of plumbing fixtures, the size and extent of the grounds, the number of horses and carriages, of domestic animals, cattle, etc., and also upon the system of supply (whether constant, intermittent, unlimited or metered). Estimates of the number of gallons to be allowed or supplied daily per capita vary greatly, but a safe average allowance for the consumption of water in American city dwellings is 50 gallons per head of population. The **actual daily consumption varies** not only on different week days, but also at the different seasons of the year, and reaches two maxima, one in extremely hot summer weather, the other in very cold weather, when much of the ordinary badly constructed plumbing work is liable to freeze unless water is allowed to run at some of the faucets. The waste involved thereby is very large, and in some of the principal cities it is almost as large as the legitimate use of water. (See Chapter VI.)

Pressure under which Water is Supplied.—The **pressure** under which water is delivered into dwellings varies in many cities and in different sections of the same city, being in some places as low as 10 pounds, while the maximum pressure may reach 90 or 100 pounds.

A very low pressure is undesirable, as it leaves the upper floors of buildings without water; a very high pressure, on the other hand, may become objectionable by reason of shocks or water hammer in the pipes, which cause the quick wearing-out of pipes, fittings and faucets.

An **average satisfactory pressure** ranges from 25 to 40 pounds per square inch; this is sufficient to supply a 3- or 4-story dwelling. A higher pressure, viz., from 45 to 60 pounds, is required, not so much for the plumbing fixtures as it is desirable for protection against fire.

Where the pressure is low or where it fluctuates at different hours of the day and night, house tanks must be used. These tanks are either supplied from the main, in those cases where the pressure becomes stronger at night, or else they must be filled by means of domestic pumps.

Chief Modes of Supply: Constant, Intermittent and Metered Systems.—Various **systems** are in use **for supplying houses with water.** In the **intermittent system** the supply is furnished only during certain hours daily, and it is shut off at the water works during the remainder of each day. This system is, obviously, both imperfect and undesirable, for it necessitates the use of large storage tanks in houses. It also compels the householder to draw the drinking-water supply from storage tanks; this is objectionable, as the water stagnates in the tanks more or less, becomes warmed, and quite often polluted by dust, vapors, sewer air, chimney gases or other agencies. For all these reasons the intermittent system has never found favor in the United States, but in many cities of England (in London, for instance) it is still in force.

The other system is the **constant system,** in which the street mains remain filled and under pressure all the time. While this may cause the items of leakage and of waste to become much larger, it is, from a sanitary point of view, far ahead of the intermittent system.

Under the constant system, there are again to be distinguished various modes, in which the water may be delivered or sold to the consumer; in one case the **supply** is **unlimited,** in the other the **supply** is **measured by water meters,** placed on the main service where this enters a house. Where houses enjoy an unlimited sup-

ply, the water tax is fixed by the frontage of the house, by the number of stories and by the number of plumbing fixtures.

In the metered system a water meter on the house-service pipe records the exact quantity consumed per day, and a fixed rate of charge for each 100 gallons of water passing through the meter (whether used or wasted) is applied. As a rule, the supply to dwelling houses is unlimited, whereas office and other commercial buildings, hotels, institutions and factories have a metered supply. Some cities, however, form an exception in having nearly all house services metered, the result being, as might be expected, a considerable reduction in the average per capita consumption.

Street-pressure and Tank-pressure Systems in Houses. There are, broadly speaking, two different methods by which the fixtures of a house may be supplied with water from the street mains, namely, the direct-pressure system and the tank-pressure system. In the first or **direct system,** which is shown in diagram, Fig. 131, a main house-service pipe is branched off from the street main, carried through the cellar, and thence vertically upward through the house to the highest floor on which it is desired to draw water, branches being taken from this rising main wherever required to supply the kitchen sink, the laundry tubs, the boiler, the bowls, bath tubs, and water-closet cisterns.

In the second or **indirect system,** illustrated in diagram, Fig. 132, nearly all the plumbing fixtures in the house are supplied from a tank located at the top of the building, the distribution tank being often the only fixture supplied directly from the street pressure by the rising main through a ball cock, which shuts off the supply when the tank becomes filled.

It is always preferable to draw water for drinking and cooking purposes, at the pantry and kitchen sinks, from the direct-supply pipe and not from the house tank, in order to obtain pure fresh water, rendered free from any suspicion of contamination by stagnating more or less in the house tank. Therefore, we find in many dwellings a combination of the two systems.

Advantages of the Tank-pressure System.—The second or **tank system,** although more expensive, because it requires more piping, **has advantages** over a direct supply, especially where the pressure in the mains is very high, causing a quick wearing-out of the faucets

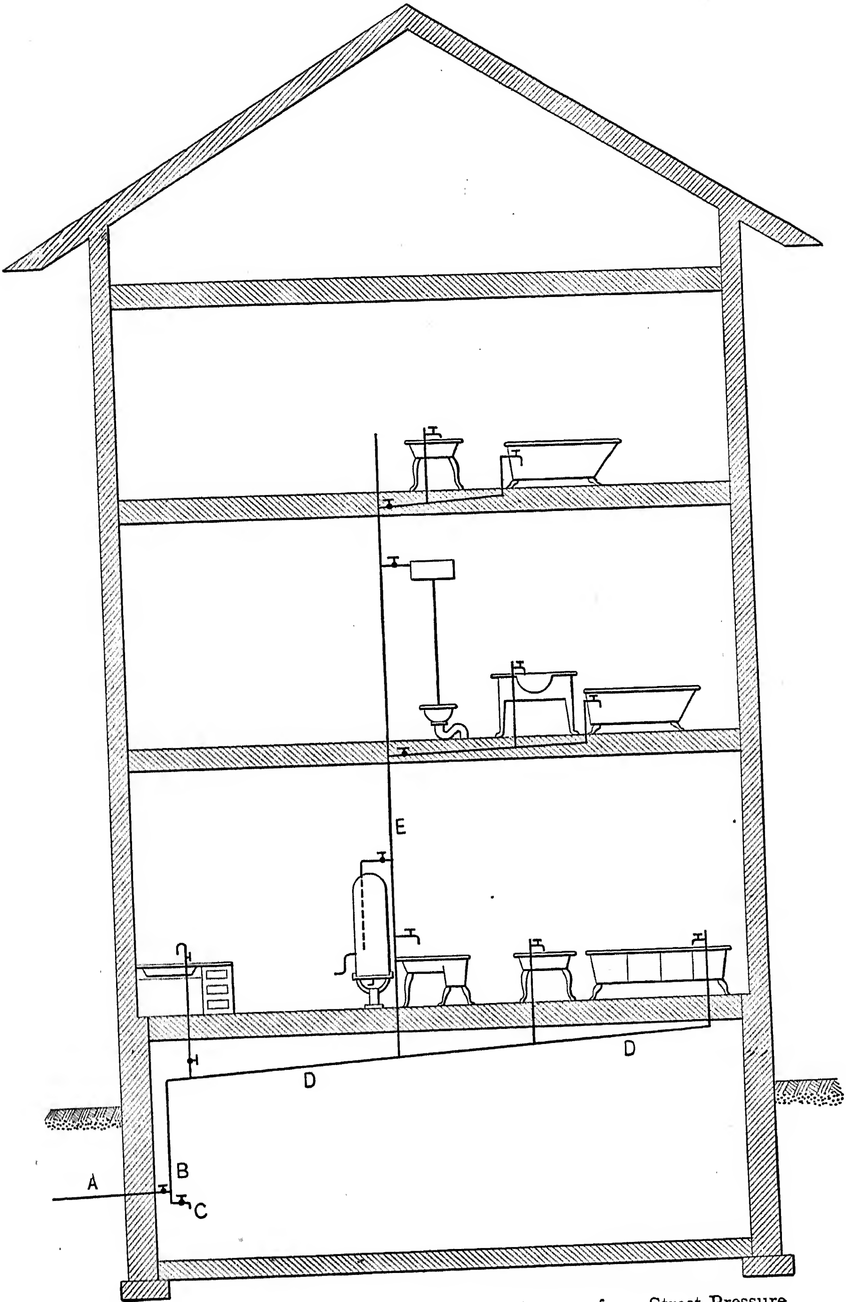


FIG. 131. Section Showing Water Supply of House from Street Pressure.

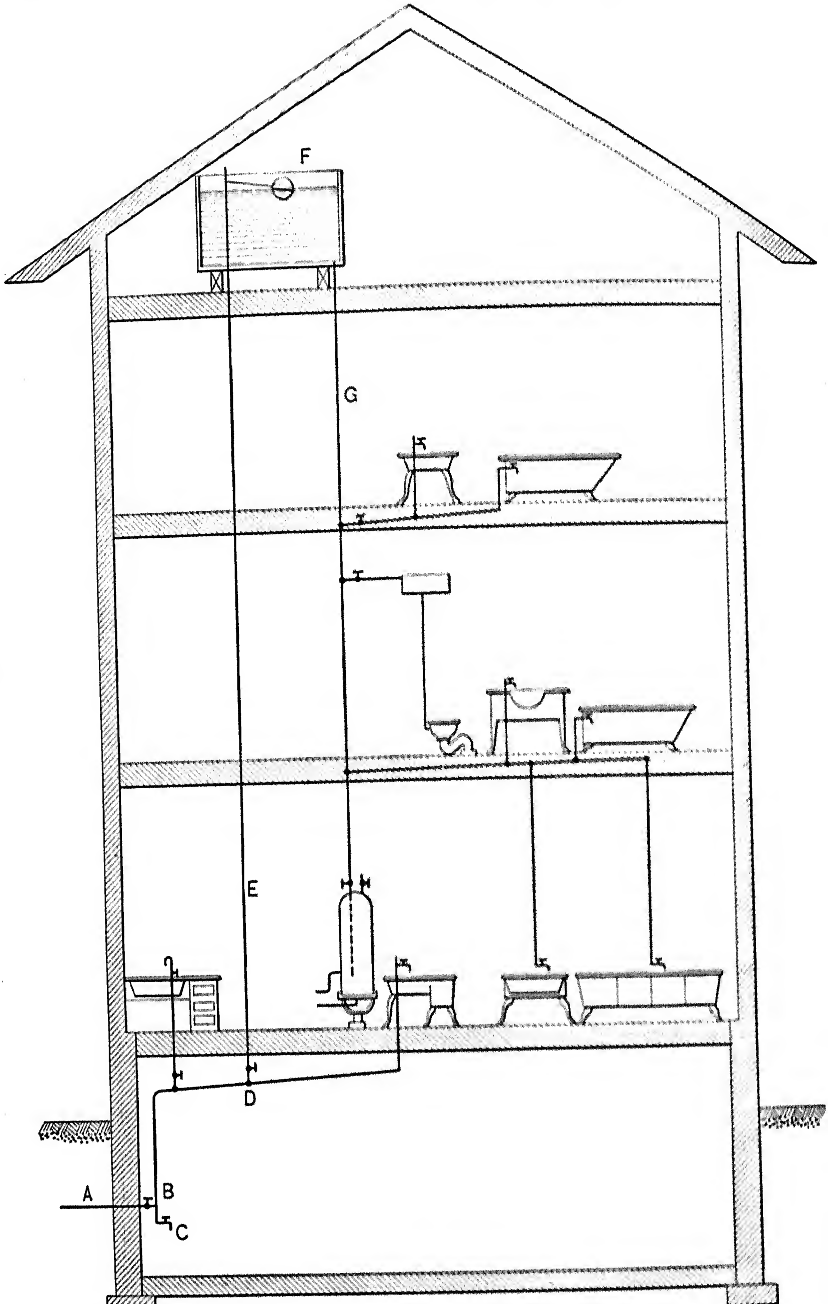


FIG. 132. Section Showing Water Supply of House from Tank Pressure.

and pipes. It is also much to be preferred in those cities where water is pumped directly into the street mains, on what is called the "Holly" system. A special feature of the "Holly" system is that, in case of a fire, the pressure in the mains is suddenly much increased, sufficiently so to throw streams of water from the hydrants to the top of very high buildings. It will be readily understood that such a severe strain brought suddenly upon the pipes, faucets, and the kitchen boiler of a house will often cause them to burst or leak, and will always tend to wear them out in a short time.

A further advantage of a tank supply lies in the fact that in case of the supply being cut off for a portion of the day, for repairs or owing to an accident to the street mains, all the fixtures will be supplied from the tank. There will be no annoyance owing to the water-closets remaining for hours, or even a whole day, without a flush, nor will there be danger of the boiler collapsing. A tank also renders a house independent of the fluctuations of pressure so frequently occurring in street mains, which often cause the upper floors of houses to be without water. Other advantages of the tank-supply system, relating to the safety of the boiler from bursting or collapsing, will be referred to more in detail in describing the hot-water supply.

A tank supply is also necessary wherever the house is supplied with water from a well or cistern by means of a lift and force pump. In some cities the pressure in the street mains is reduced, owing both to the large consumption and the increasing waste of water, to such an extent as to permit the water to rise only to the lower stories of a house. In this case, too, a tank is required in the attic to supply the fixtures on the upper floors.

House Tanks for Storage of Water.—**Storage tanks for water** are either **supplied from the street main** under pressure, or else they are **filled by pumping,** either from the general supply or from a local source such as a well, spring or cistern. When the water does not require to be lifted to the tank by pumping, but flows into it by pressure from the street mains at all times, it is not necessary to use a very large tank, for its chief purpose, in such case, is to supply the fixtures with a moderate and steady pressure. In other words, the tank is to be looked upon simply as a distributing, and not as a storage-reservoir. In fact, the smaller the tank is

made the oftener will its contents be renewed, and hence the water will not be so apt to acquire a bad taste, owing to stagnation and lack of aëration. Tanks of larger capacity are required where the water must be lifted by pumps, or where the tank fills only during the night.

In all houses having house tanks it is desirable to have some **faucets,** generally those located on the lower floors (kitchen, pantry,

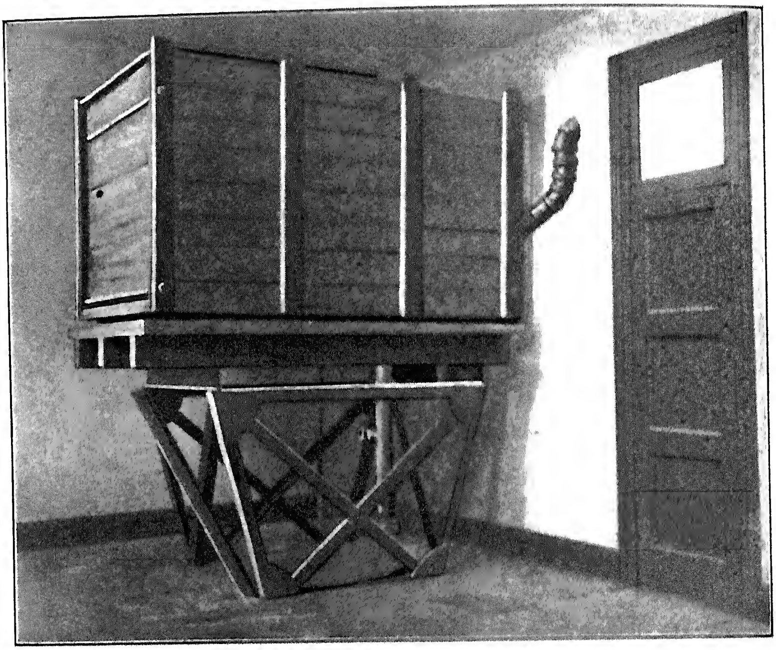


FIG. 133. View of a House Tank.

and the sillcocks), **supplied directly from the main.** At these faucets the water for drinking and cooking purposes should be drawn.

The tank is placed in the attic (Fig. 133) in an easily accessible position, and in a room well protected in winter time against frost, or else it is placed on the roof, in which case a special tank or pent-house is sometimes provided. Tanks are made either of strong two-inch boards or planks, or else of narrow 2″ × 4″ strips, placed one above the other, and dovetailed at the corner. They are then lined on the inside by the plumber with tinned sheet copper, weigh-

ing 16 ounces, or 1 pound, per square foot. In the cheaper class of houses, tanks are often lined with sheet lead. But lead is readily attacked and dissolved by some waters, therefore it is much better not to run any risk, and rather to pay the small difference in extra expense for a good tinned-copper lining.

Roof tanks are often constructed of cypress or white-pine staves, doweled together and held by stout hoops. In larger buildings, water tanks are often made of iron, either of boiler-iron plates, tightly riveted together, or else of cast-iron sectional plates, put together with bolts and cement at the joints. Plain iron tanks soon discolor the water, owing to the rusting of the iron, and it is therefore necessary to protect the surface of the iron, which may be done by applying metallic paints, or else by treating the iron with a rustless process.

Water tanks in houses should not be of galvanized iron, nor of wood lined with zinc, for water readily forms chemical combinations with this metal, and the resulting zinc salts are, to some extent, poisonous, if introduced into the human system. Slate is an excellent material for tanks, but it is much more troublesome to make such tanks tight, and hence they are not ordinarily adopted.

Details of Tank Pipe Connections.— Where a tank is to be supplied with water from the rising main (Fig. 134), this is accomplished by means of a **ball cock.** (Fig. 135). The operation of this device is as follows: When the tank is empty the hollow copper-ball float hangs

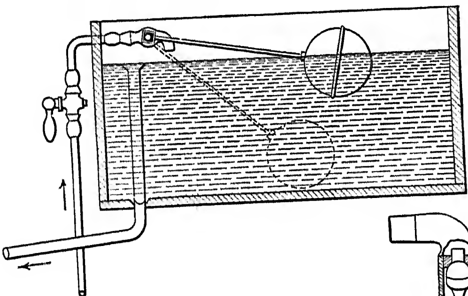


FIG. 134. House Tank with Ball Cock Supply.

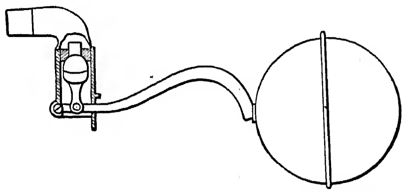


FIG. 135. Sectional View of Ball Cock.

down, and the service cock is open. If the water is now turned into the tank by opening a stopcock on the rising main, a full stream is discharged at the cock, until the water has risen in the tank to a height sufficient to

float the ball. As this is placed at the end of a long lever attached to the supply cock, the rising of the ball causes a gradual shutting of the latter, until, when the water reaches the fixed water line, located some inches below the top of the tank, the cock is entirely and tightly shut off. As fast as water is being drawn for house use from the tank, the water level falls again, and simultaneously the ball-float drops, and thus opens the cock until the tank is refilled.

Water is drawn from the tank by means of a pipe, entering at its bottom and protected against obstructions by a strainer. This pipe, supplying all the house fixtures including the boiler, is termed the **falling main** to distinguish it from the **rising main.** The latter always contains water under pressure from the street mains, while the falling main has water under a pressure corresponding to the elevation of the water line in the tank above the point where water is drawn. Thus, if the pressure in the street main at the house is equivalent to a head of 125 feet, and if the ball cock is located 40 feet above the street main, the water will pass into the tank with a pressure, at this point of the rising main, equivalent to 125 − 40 = 85 feet head of water, or about 36.8 pounds pressure per square inch. On the other hand, if the water level in the tank is 30 feet above the faucets of the laundry tubs, the pressure of water at this point of the falling main will be equivalent to a head of water of 30 feet, or about 13 pounds per square inch. (See Diagram Plate 23, Appendix.)

Tank Valves.—It often becomes desirable, in case of repairs to pipes or faucets in the house, to shut off, temporarily, the supply from the tank in order to empty the pipes. This may be accomplished by cutting off the direct supply at the rising main and emptying the tank by opening any of the faucets on the first story, but it would be a rather slow and awkward proceeding. It is much preferable to provide a shut-off in the falling main, directly underneath the tank outlet. There are two ways in which this may be arranged. In the first method, shown in Fig. 136, a cistern valve, resting on a valve seat tightly fastened at the tank bottom, is employed; it is operated by means of a pull, lever and crank fixed over the top of the cistern. An important adjunct of this valve is the small air tube carried from below the valve-seat above the top of the water in the tank. If this were not provided, water would not readily run out of the faucets and the falling main and its branches could not be

emptied. The air tube serves, as its name implies, to bring the atmospheric pressure to bear upon the water column in the pipes, which latter will fall upon opening any of the faucets supplied from the falling main.

In the second method, shown in Fig. 137, a plain water valve or else a lever-handle stopcock is used to shut off the water in the tank. The valve or stopcock must, of course, be put in an accessible

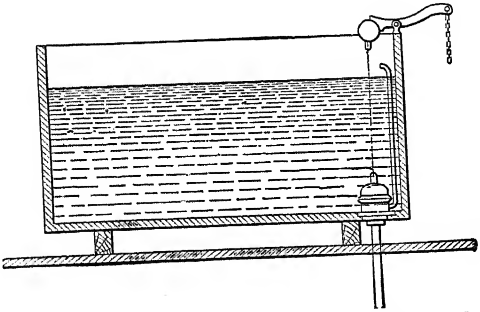


FIG. 136. Arrangement of Cistern Valve in House Tank.

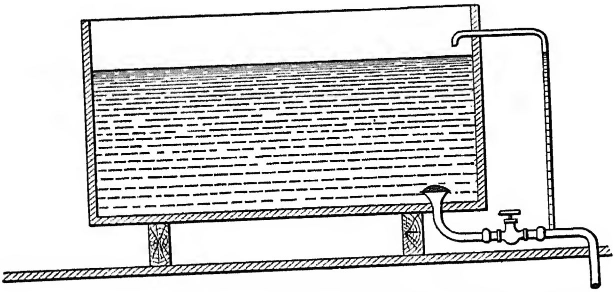


FIG. 137. Arrangement of Pipe Connections at House Tank.

position, and in this case, too, an air pipe should be carried from below the stopcock or valve to the top of the tank, as otherwise it will be found difficult to empty the pipes.

Tank Overflow.— Every tank requires a pipe of sufficient capacity to remove safely any overflowing water in case the ball cock should leak or refuse to close properly. It is of the utmost importance that this **overflow pipe** be not connected with any drain, soil, waste or vent pipe, for water is a ready absorber of foul gases which may be contained in the waste-pipe system, and hence it is absolutely necessary that the overflow be disposed of in a harmless and safe manner.

It was formerly quite common to trap the overflow pipe with a deep-seal trap and then to lead it to the nearest soil or waste pipe. This practice is faulty and utterly to be condemned, for the water in the trap will ultimately evaporate, no matter how deep a seal it has, and if no overflow occurs — and it ought not to occur with a tight-shutting, well-fitted ball cock of good construction — an open road will be established for air from the soil pipe to the tank.

Much the easiest manner of disposing of the overflow is to run and discharge it into the nearest roof gutter or on the roof. If this is found impracticable, the overflow pipe should be carried to the nearest sink or plumbing fixture, where its discharge would be in sight, so as to call attention to the leak in the ball cock. The overflow pipe is either taken out at the side of the tank above the highest water level or else arranged as a standpipe overflow, standing in the bottom of the tank and reaching up to the water level, its upper end or mouth being flared out, as this helps in catching the overflowing water. The standpipe overflow (see Fig. 134) has this important advantage: that its full area at once comes into play, whereas the ordinary overflow requires the water to rise to the top of the pipe before its entire cross-sectional area becomes effective. If the top of the stand-pipe overflow is made with flaring or trumpet-shaped mouth, it will discharge much more water than if made cylindrical.

Tank-emptying Pipe. — Where water is muddy or carries finely suspended organic or inorganic matters, these will settle at the bottom of the house tank. In such a case it is quite necessary to empty and clean the tank often and thoroughly. To empty the tank by means of the falling main would be objectionable, as the muddy deposit of the tank would thereby be carried into the distribution pipes, involving the danger of stoppages. This could partially be obviated by keeping the outlet leading to the falling main at a height of at least six inches above the tank bottom, but such an arrangement would render it impossible to remove all the water from the tank. It is to be recommended, therefore, to fit the tank with a **blow-off or emptying pipe** of large size, leading from the tank bottom to the same place where the overflow is carried. It is even possible to combine both, by using a standing tube for

the overflow pipe (see Fig. 134). If it is desired to empty the tank the tube is simply lifted and removed.

Arrangement of the Hot-water Supply from the Kitchen Boiler. — The following will serve to explain the manner in which the **hot-water system** in a dwelling house is usually arranged. A **hot-water boiler** *E* (Fig. 138) is placed on a stand *H* in the kitchen alongside of the range. This boiler is a closed cylindrical vessel, able to stand a strong pressure of water, and serves as a reservoir for hot water. The fire in the kitchen range is utilized to heat the water by placing a closed vessel of iron, *C*, usually termed a **water back,** and which sometimes consists of a cast-iron box, at other times of a pipe coil, in a corner or at the side of the fire pot so as to have the fire pass over its side. This water back is connected with the boiler by two pipes—a cold-water feed and a hot-water return pipe. A good circulation is obtained by making the upper or return pipe from the water back to the range a size larger than the lower one. In ordinary work, the connecting pipes are made of lead, but brass or copper pipes are preferable.

Properly speaking, the water back should be named "boiler," for this is the vessel in which the water is heated, while the so-called "boiler" is simply intended as a vessel capable of storing hot water until it is drawn off at the plumbing fixtures.

The boiler, *E*, is supplied with cold water by means of a pipe, *A*, which enters the boiler at the top, but is continued inside of the boiler to within a few inches from its bottom. The lower part of a boiler contains, consequently, cold water. From the bottom of the boiler a pipe, *B*, leads the cold water to the lower opening of the iron water back. Here it becomes heated and rises, returning by means of another pipe, *D*, from the upper outlet of the water back into the boiler at a point above the inlet for cold water. The heated water ascends to the top of the boiler, sinking toward the bottom only as it becomes cooled by emission of heat from the boiler. The main circulation between the boiler and the water back begins as soon as a fire is lighted in the range, and goes on as long as the fire is kept burning. A second circulation of less importance is kept up within the boiler itself, as indicated heretofore. The hot water pipe *F* (sometimes one and often several pipes) is taken out from the top of the boiler to carry water to the points at which

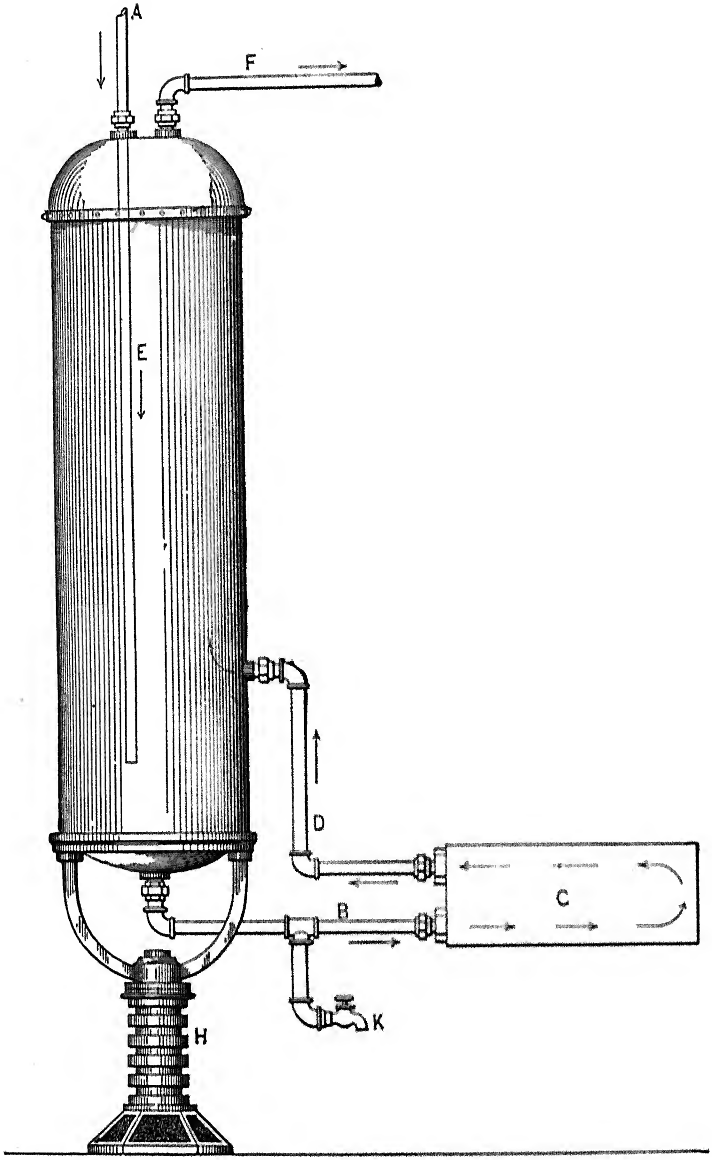


FIG. 138. Common System of Connection Between Kitchen Boiler and Water Back.

it is desired to draw it. The top of the boiler is usually of a dome-head shape, as this makes it stronger than if made with a flat head. The top should be fitted with several couplings of suitable size for connection with the pipe system of the house.

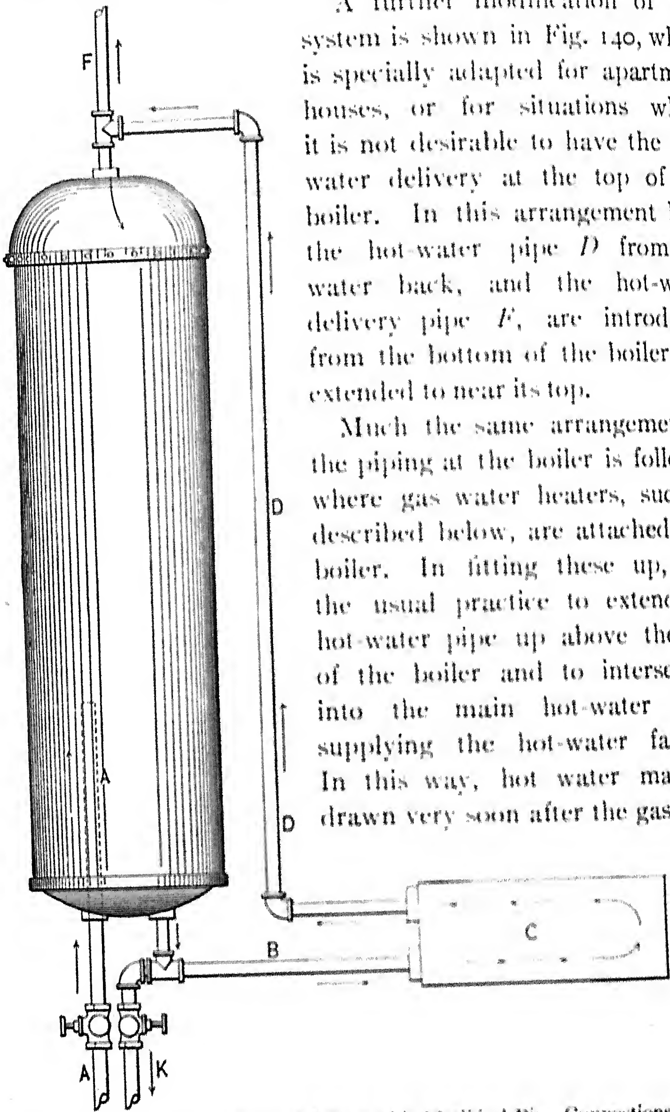
With muddy water a good deal of sediment and mud, forming sometimes an incrustation, collect at the bottom of the boiler, and it becomes necessary to blow the water off at times. This is accomplished by arranging at the lowest point of the pipe, leading from the bottom of the boiler to the water back, a **sediment cock,** *K*, to which a hose may be attached if it is desired to blow off or empty the boiler. This blow-off pipe is, at times, connected to the nearest waste pipe, or run into the trap of the kitchen sink, but I prefer to have absolutely no direct connection between a water pipe and any waste pipe. I advise running this emptying pipe to a cellar sink, or it may be connected with a refrigerator waste, and thus help to flush the latter at desired intervals. Often an emptying cock is provided at the bottom of the boiler, and if it becomes necessary to open the sediment cock, a pail may easily be placed underneath it, or else a hose may be attached to it, leading the water outdoors. To prevent any outsiders from meddling with the cock, it is advisable to remove its handle.

One objection to the ordinary form of range and boiler connection is that the hot water, generated in the water back, enters the boiler at the side coupling, located at about one fourth or one third of the height of the boiler (Fig. 138). The heated water, when the fire is first started, must consequently pass through a large body of cold, or at least colder, water, thus losing some of its heat. As a natural result it follows that the entire boiler takes longer to heat up.

This objection was overcome in the **modification** introduced many years ago in the "Creque" boiler, which is so arranged that the hot-water pipe from the water back is carried directly to the top of the boiler (see Fig. 139). In this way the hot water does not mix with the cold, but gradually accumulates at the top of the boiler and from there downward. The result is that a body of very hot water is secured without any delay.

The cold-water supply enters the boiler through pipe *A*, from the bottom upward. When a faucet is opened, hot water is forced

out at the top of the boiler, and it is not necessary to wait for hot water until the entire body of water in the boiler is uniformly heated.



A further modification of this system is shown in Fig. 140, which is specially adapted for apartment houses, or for situations where it is not desirable to have the hot-water delivery at the top of the boiler. In this arrangement both the hot-water pipe *D* from the water back, and the hot-water delivery pipe *F*, are introduced from the bottom of the boiler and extended to near its top.

Much the same arrangement of the piping at the boiler is followed where gas water heaters, such as described below, are attached to a boiler. In fitting these up, it is the usual practice to extend the hot-water pipe up above the top of the boiler and to intersect it into the main hot-water riser, supplying the hot-water faucets. In this way, hot water may be drawn very soon after the gas is lit.

FIG. 139. "Creque" Kitchen Boiler with Modified Pipe Connections.

The Brooks range boiler (see Fig. 141), made by Jas. B. Clow & Sons, is another modification embodying new features in the method of connecting the pipes. The cold water enters the boiler throug

valve A at the bottom and passes up into it through pipe B, until at C the direction of its flow is reversed by an outer pipe. Now the water flows downward and out at D. The water leaves the boiler at pipe E and goes through pipe F to the water back, there to become heated, and returning thence to the boiler at point and coupling G. Here it enters the boiler and passes upward through the pipe H to the top of the boiler. Entering the boiler at K it finds immediate outlet at L, from where it flows downward through and out at M.

The tendency for the hot water is to remain at the top. The cold water, on the other hand, has a downward direction of flow, and, as its natural tendency is to fall to the bottom, the hot and cold water practically remain unmixed. Thus, as soon as there is any hot water in the top of the boiler, water may be drawn *hot* at any faucet in the house.

The chief advantage of the Brooks boiler is, therefore, that hot water can be drawn in a few moments after a fire is lighted, owing to the novel method of circulation. Another

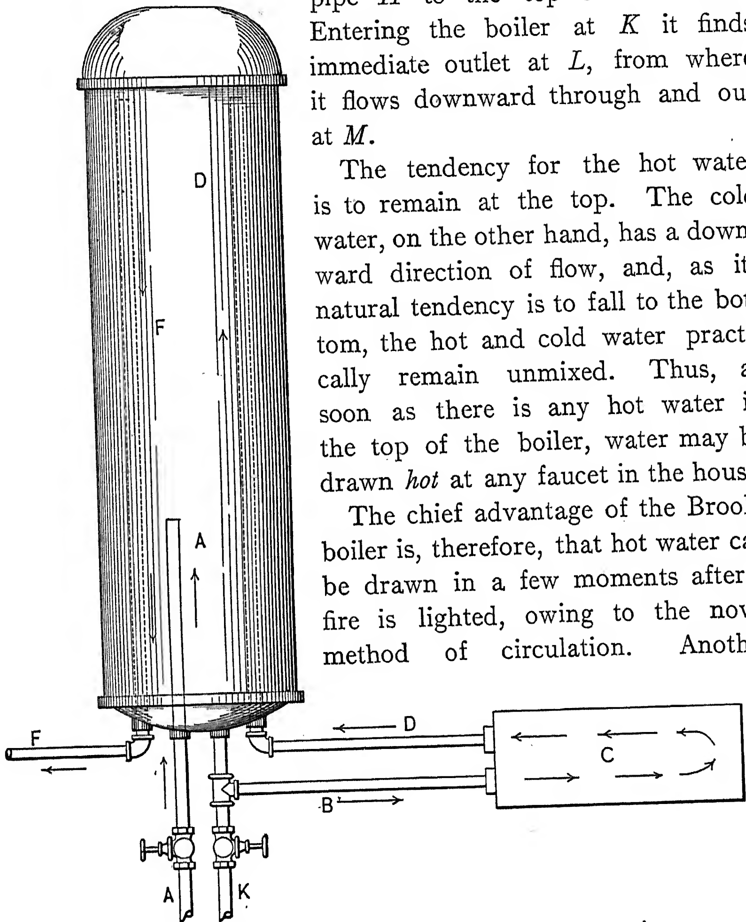


FIG. 140. Another Modification of Kitchen Boiler Connections.

advantage is that the pipe connections are on the inside of the boiler and so all unsightly pipes are done away with. Valve R is for emptying and cleaning the boiler, and should ordinarily always

be kept closed. The inside pipes can be easily withdrawn for repairs. The same style of boiler may also be connected with a gas range.

Kitchen Boilers Supplied from Tank Pressure. The pipe *A* (Fig. 138), which supplies cold water to the boiler, may be connected either to the rising main, thus supplying the boiler by direct or street pressure, or else it may be a part of the falling main, where the **boiler is supplied from tank pressure** (see Fig. 142). The latter system is far preferable, as already indicated, for the following reasons: If a boiler is supplied from direct pressure, the danger always exists of its leaking or bursting under a heavy water pressure, or owing to repeated shocks of water hammer. Moreover, the water back may create a large amount of steam, if the proportion between size of water back and capacity of boiler is ill chosen, and particularly when the water back is far too large for the work it has to do. This will not only cause the rumbling noise so frequently encountered in kitchen boilers, but, if the fire is very brisk, it may bring with it the danger of the boiler bursting.

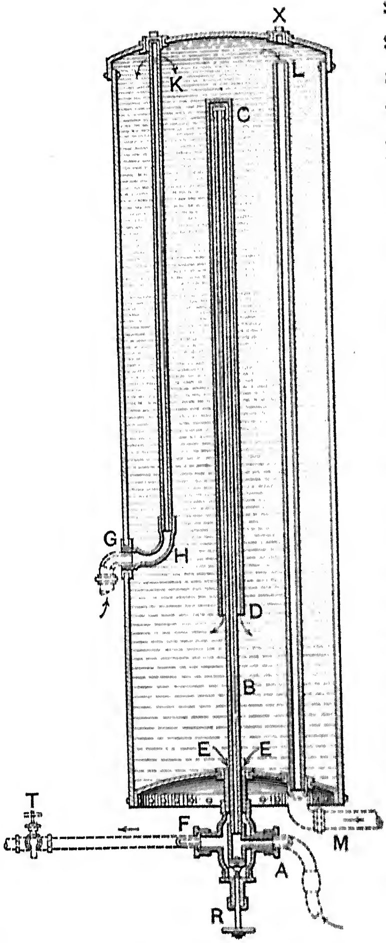


FIG. 141. Arrangement of Pipe Connections in the Brooks Kitchen Boiler.

Another danger to which boilers, supplied from the street pressure, are subject, is that of **collapsing.** This may occur if a water faucet is suddenly opened, whereby the cold water entering the boiler condenses the steam and thus very suddenly creates a vacuum,

whereupon the atmospheric pressure on the outside exerts a crushing force on the boiler shell. The latter is rarely strong enough in copper boilers to prevent their entire collapse, and this is one of the reasons why the cheaper, but stronger, iron boilers are used where houses are supplied on the direct system. The same accident may happen to boilers if the water is removed from them by means of the sediment cock, without taking the precaution of opening the kitchen-sink faucet in order to prevent the creation of a vacuum. When water is drawn off in the street mains without warning being given to the occupiers of dwellings along the street, boilers supplied from the street pressure frequently collapse. If proper warning is given, the householder should not neglect to shut off the house-supply pipes and to put the fire out in the range.

Boiler Vacuum and Safety Valves. — To prevent the bursting and the collapsing of boilers supplied directly from street pressure, a **combined vacuum and safety valve** is sometimes placed at the top of the boilers. The safety valve is intended for the escape of steam generated in the water back or boiler, while the vacuum valve is so arranged as to admit air in case a vacuum should occur at the inside of the boiler. I do not have much faith in the proper working of such kitchen-boiler appendages. Unlike the safety valve of a steam boiler, such a device is not constantly looked after, nor is it sufficiently often put into operation, hence the valve is very liable to stick just at the time when it is required to blow off steam. In short, the arrangement cannot be recommended, as it is rarely efficient, and gives rise to a false sense of security. In my judgment, kitchen boilers ought always to be supplied from tank pressure.

Fig. 142 illustrates the proper **system of arranging the pipes for a boiler supplied from a tank.** The tank is shown located on the highest floor of the house — though it is more often placed on the roof. It has a ball-cock supply, *a*, an overflow and a blow-off pipe, cistern valve and air tube on the falling main, *b*, and pull, lever and crank. The black lines indicate cold-water pipes, *a* being the rising main, *b* the falling main, supplying the boiler. Pipe *c* is the rising-hot-water main, *i.e.*, the pipe leading the hot water from the top of the boiler to the fixtures on the upper floors.

Steam-relief or Expansion Pipe.— An essential feature of the tank-supply system is the **steam-escape or relief pipe** *d* for the kitchen

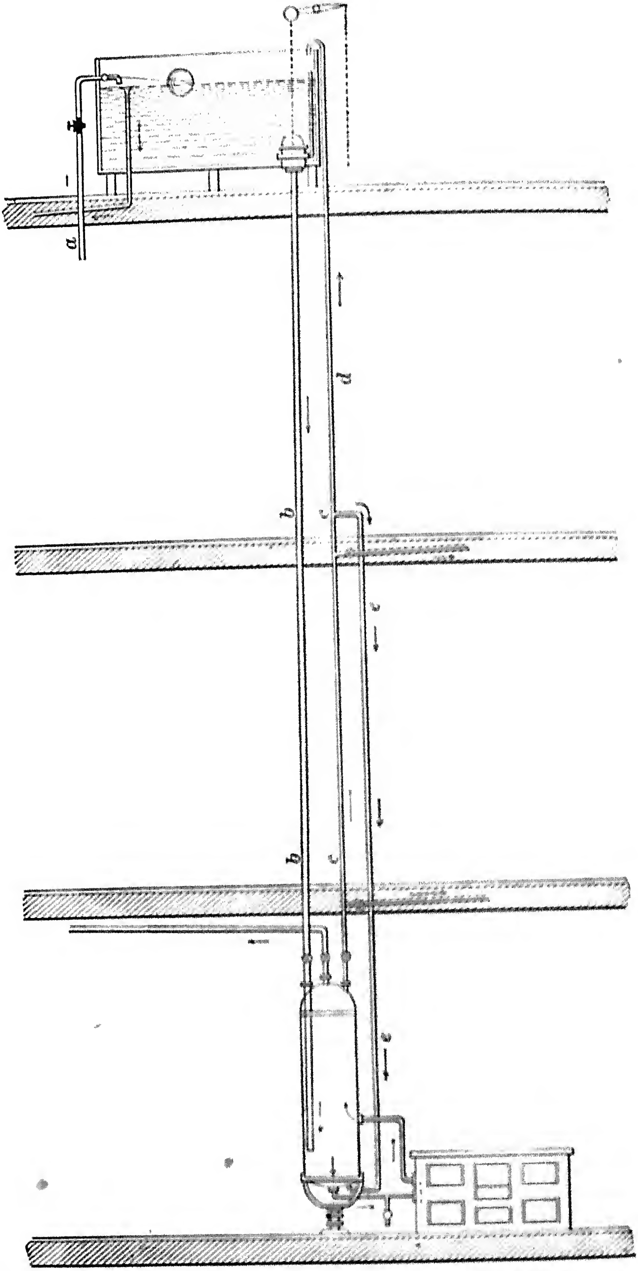


FIG. 142. Arrangement of Kitchen Boiler Connections from Tank Supply.

boiler. This is simply an extension of the hot-water rising main to a point carried well above the water level in the tank, which is there bent over, its end remaining open for the escape of hot water or steam into the tank. It is necessary that this escape pipe be carried to some height over the tank, as the hot water stands higher in the pipes than the cold-water level in the tank, owing to expansion. If this is not done, there is danger of the hot water flowing over into the house tank.

The object of the expansion pipe is twofold. In the first place it renders the boiler safe against explosion, as any surplus of steam generated in the water back can readily escape at the open end of the relief pipe. Secondly, it efficiently prevents the collapsing of a boiler, as it serves to admit air to the boiler in case the water is drawn out. It is usual to make the steam-escape pipe of a small diameter, but I much prefer to retain for it the full diameter of the hot-water rising main. This increases the expense a trifle, but it also adds to the security of the boiler.

One of the advantages of the tank over the direct-supply system to kitchen boilers is that it permits the use of a steam-escape or relief pipe, for where no tank is used there can be no relief pipe. The substitute for this device, consisting in the above-described boiler vacuum and safety valve, placed on the top of street-pressure boilers, is not nearly as good.

Return Circulation.— Another pipe (marked *e* in Fig. 142) is often run from the hot-water pipe supplying the highest fixture in the house back into the bottom of the boiler. This is called a **return or circulation pipe.** Its object is to enable a person to draw hot water almost instantly from any faucet situated at a great distance from the kitchen boiler. If the hot-water pipe stops, as it usually does in ordinary house plumbing, at the highest fixture, the hot water contained in the long stretch of pipe soon loses its heat, and it becomes necessary to allow a more or less large amount of water to run to waste before obtaining hot water. By adding the return-flow pipe *e*, a constant circulation is kept up in the hot-water distribution system, the water flowing back to the boiler through this pipe as it cools, and being constantly replaced by hot water rising from the top of the boiler.

Another important advantage of the return-circulation pipe is

that it prevents waste of water in houses, inasmuch as the faucets need not be kept running to draw out the water which has, by standing in the pipes, become cooled. Still another advantage is that it tends to maintain a more even temperature in the hot-water boiler, and also that it relieves the boiler from any undue pressure due to the water getting too hot.

Explosion of Water Backs.—There is one danger to which hot-water apparatus of all kinds is subject, and that is the **bursting of the water back** in winter time. One frequently encounters in newspapers accounts of such explosions, which are often the cause of serious injuries to the kitchen servants or, at least, of damage to property. Such accidents are liable to occur whether a boiler is supplied from direct pressure or from a tank, and they can be prevented only by some intelligent care on the part of the householder. The reason for such an explosion, which very often causes the entire destruction of the cooking range, is a very simple one.

If the kitchen fire is allowed to go out on a very cold night, particularly if the kitchen is much exposed, the water in the water back and the connecting pipes may freeze. If the fire is lighted in the morning, steam is generated in the water back, and, inasmuch as the circulation is interrupted and the steam has no exit from which to escape, a powerful pressure is exerted upon the water back until it finally explodes with great violence. It should be understood that neither vacuum nor safety valve, nor the expansion pipe of the tank-supply system, render the system free from the danger of this accident.

The only sure way to prevent the occurrence of such a disaster is to keep, on cold nights, a fire going in the range, so as to maintain the circulation of water through the water back. If the fire should accidentally or carelessly be allowed to go out in winter time, it may be a wise precaution to ascertain in the morning, before lighting a fire, if the water is frozen in the connecting pipes between the boiler and the water back. This can be done, when the pipes are properly arranged, by opening the sediment cock, which should be placed close to the range. As long as water is delivered from it, it is very probable that the water in the water back is not frozen, as the freezing would begin at the pipes, not at the water back, for the range is apt to retain some of its heat for a long time.

Material of Kitchen Boilers.— Kitchen boilers are made of **riveted wrought iron** and of **copper.** If of iron they are always **galvanized,** in order to prevent the iron from rusting. If of copper they are tinned on the inside. In neither case should water for culinary operations be drawn from a boiler.

As commonly made, galvanized-iron boilers are able to withstand a heavier pressure than copper boilers; for this reason they are usually selected wherever the supply is directly from tank pressure. There is very little danger of such a boiler collapsing. I, however, much prefer a copper boiler, which can also be had, although at a greater expense, of sufficient strength. Such a boiler should always be subjected to a heavy-pressure test before being put to use. If supplied from a tank under a uniform and moderate pressure, as is preferable for reasons already stated, and if arranged as above recommended, and as shown in Fig. 142, it is free from the danger of collapsing or bursting. Boilers should be set on a galvanized cast-iron boiler stand, of such a height as to bring the bottom of the boiler slightly above the lower water-back connection.

The **size of the kitchen boiler** depends upon the number of plumbing fixtures to be supplied with hot water; also, to some extent, upon the size of the range and water back. A large water back requires a large boiler to avoid the undue generation of steam and the quick wearing-out and cracking of the hot-water pipes near the dome-head of the boiler.

In some cases it has been found advantageous to cover the kitchen boiler with non-conducting covering. This retains the heat in the water, and also tends to keep the kitchen cooler. If the covering is neatly applied, it does not necessarily mar the appearance of the boiler in the kitchen.

Hot-water Supply from Two Boilers.— Larger houses often have **two hot-water boilers,** one in the kitchen, the other in the laundry. Sometimes the laundry boiler is intended for hot-water supply to the laundry tubs only, but in many cases the two boilers are cross-connected, so as to supplement each other. This arrangement works well as long as a fire is made each day both in the kitchen and in the laundry. If there is no fire in the laundry stove, the water drawn at hot-water faucets will be a mixture of hot and cold water, unless a valve is closed to shut off the laundry boiler.

As it is not desirable that servants should manipulate valves in a house, the arrangement cannot be recommended. Where two boilers are used, it is very much better to feed the smaller boiler (usually the one in the laundry) from the hot-water pipe of the kitchen boiler, and to provide a return circulation between both boilers.

Another method which I have often used with good results is to have an interchangeable connection so that either laundry-boiler or kitchen-boiler hot water may be drawn at the tubs.

The laundry boiler is apt to become overheated on ironing days: to utilize the hot water generated at that time, it is a good practice to arrange for a third faucet at the kitchen sink, so that the cook may draw hot water from the laundry boiler, in this way saving the entire contents of the kitchen boiler for the fixtures in the bathrooms.

Both boilers may be fitted up either in a vertical or in a horizontal position, and the latter position is chosen where space is lacking.

Cellar Hot-water Tanks.— Of late years, it has become customary to do away with the kitchen boiler, or with both kitchen and laundry boilers, and to obtain the entire supply of hot water for the house from a **hot-water tank in the cellar.** This arrangement has several distinct advantages and only one slight disadvantage. The latter is the necessity of attending the year round to a fire in the cellar. Many house owners do not find this to be a troublesome matter. The advantages gained, on the other hand, are that the kitchen does not become overheated from the heat radiated by the boiler; also that, as there is no water back or pipe coil in the fire box, the ovens will receive a larger amount of heat and hence will bake better.

The cellar hot-water tanks may be heated by steam coils placed on the inside, and supplied with steam of about five pounds pressure; but, as steam is not available in summer time, a summer or hot-water heater is added to the arrangement, which is capable of heating the entire contents of the tank by rapid hot-water circulation.

Sometimes two such tanks are provided, one for street, the other for tank, pressure (see Fig. 143).

Where high pressure or exhaust steam is available all the year round, a **hot-water heater,** designed much in the same manner as a feed-water heater, is sometimes installed. Its capacity should be

made very generous, for as is well known, feed-water heaters do not have a large storage capacity for hot water, and hence must make up in heating capacity what they lack in storage capacity.

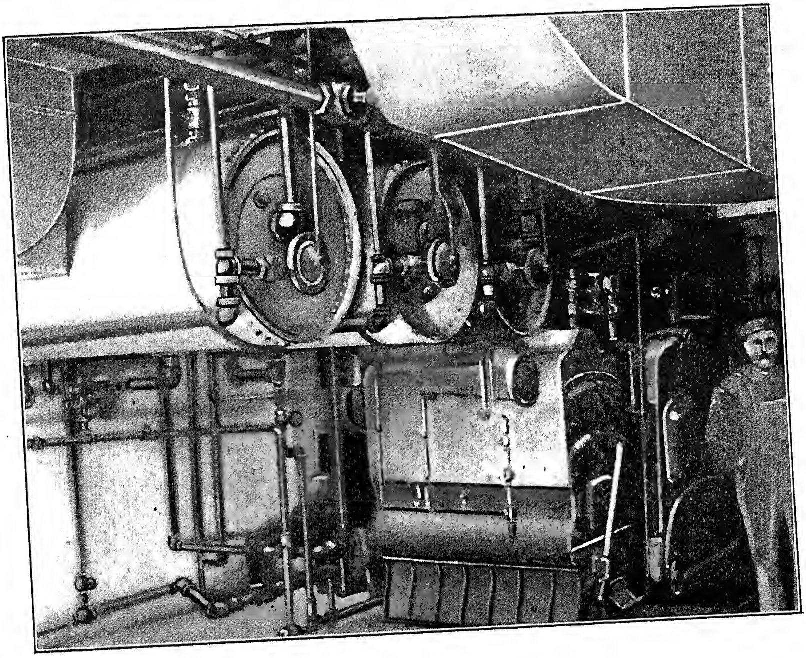


FIG. 143. View of Hot-water Tanks Heated by Steam.

Gas Water Heaters. — Gas water heaters for the supply of hot water are of three different types. The so-called **instantaneous heaters** (Figs. 144, 145 and 146) are used in bathrooms or at other fixtures, and are arranged so that when the cold water is turned on the gas is ignited simultaneously and hot water begins to flow almost immediately at the spout or nozzle. It should be understood that such instantaneous heaters have no connections to the hot-water pipes, and require only a cold-water and a gas connection.

Another type of gas water heater is used as an attachment to the regular kitchen boiler. It is usually set alongside of the range, but may be set in the cellar if more convenient and then connected with the boiler.

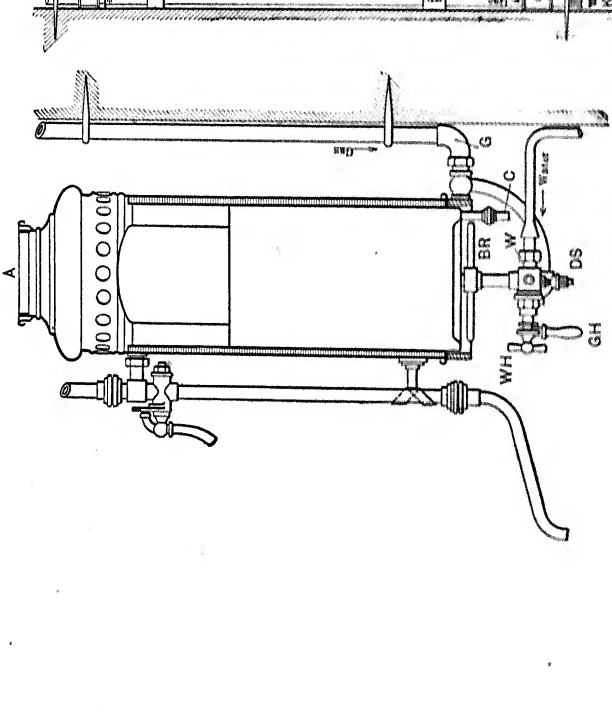


FIG. 144. Prof. Junker's Instantaneous Gas Hot-water Heater.

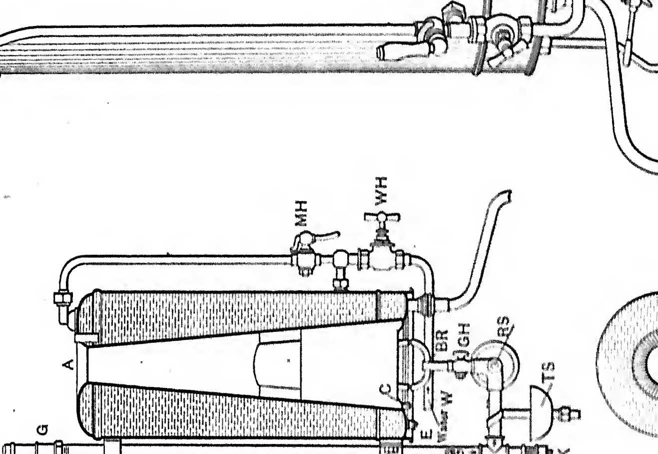


FIG. 145. Prof. Junker's Instantaneous Gas Hot-water Heater.

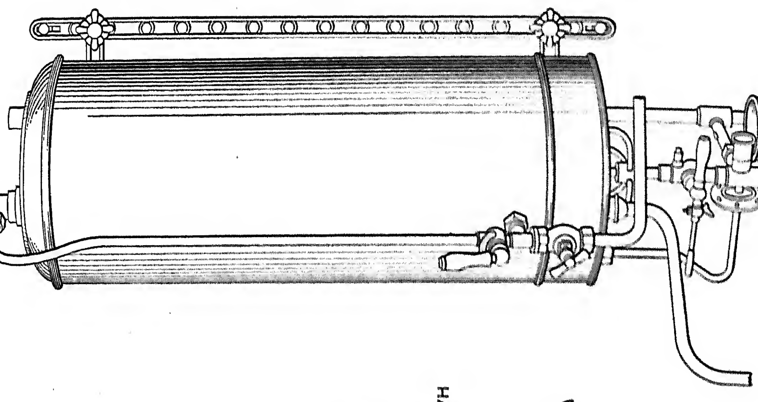


FIG. 146. Larger Size of Prof. Junker's Gas Water Heater.

Such **round water heaters** are of many different makes. One heater of this type, illustrated in Fig. 147, consists of a vertical cylinder or water chamber containing many tubes placed on the inside in a perpendicular position. A large atmospheric gas burner is placed at the bottom, and the heat from the gas passes upwards the entire length of the tubes. The cold water enters the upper chamber and, passing down through the inner tubes, returns through the outside tubes and, after passing through the lower chamber, it flows heated from the top of the heater. The sectional view, Fig. 148, explains clearly the working of the heater.

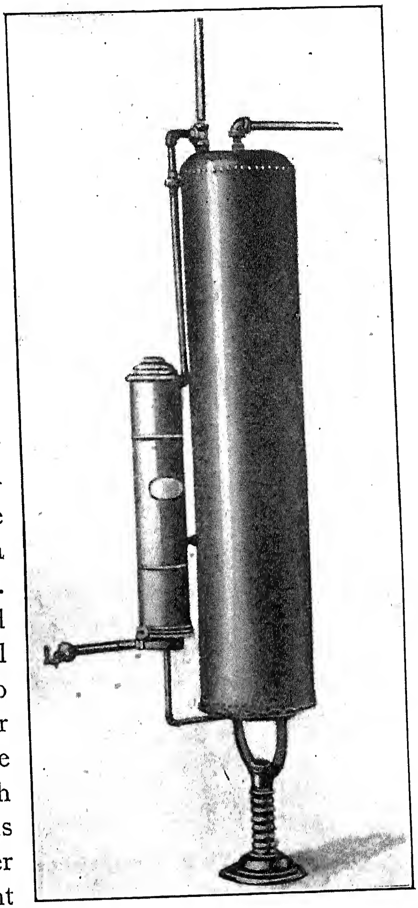


Fig. 147. Eclipse Gas Water Heater Attached to Kitchen Boiler.

When set up alongside of the boiler, these heaters do not occupy much space and the pipe connections can be readily made. The heaters, although small, have a very large inner heating surface. The outside jacket is of planished steel, the inner of cold-rolled steel and lined with asbestos, as is also the outside jacket, with an air space between. In this way the loss of heat by radiation is much reduced. The gas burner is specially designed for the heater and adjusted to consume the right amount of gas to obtain good heating results. These heaters are made in several sizes, to be in proportion to the capacity of the boiler. Where the boiler exceeds eighty gallons capacity these types of heaters are not so well adapted. In all cases the hot-water connection to the boiler should be made at the top, as explained in Fig. 139, in order

to draw hot water quickly without having to wait until the boiler is heated.

The third type of gas water heater may be described as an **independent** and **automatic gas heater,** which is usually fitted up in the cellar, and connected with the main hot-water lines of the house.

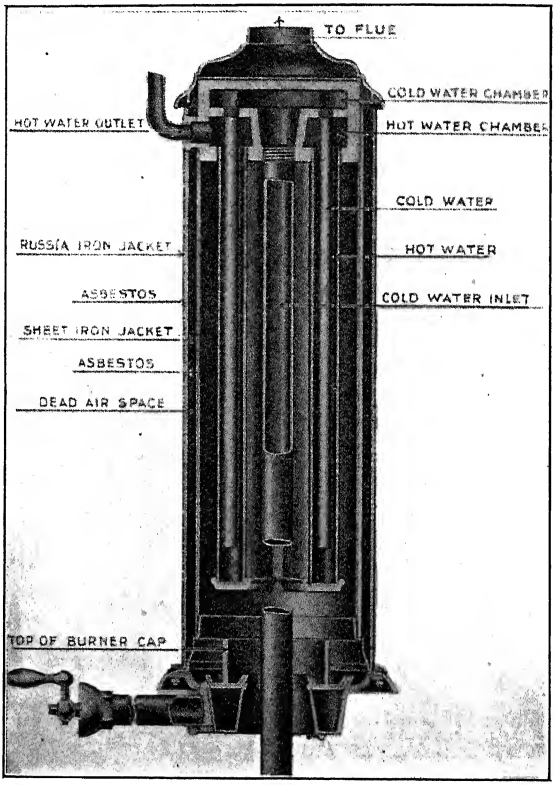


FIG. 148. Section of Eclipse Gas Heater for Kitchen Boiler.

Besides the two principal makes of these heaters, the Pittsburgh and the Ruud heaters, which I shall describe and illustrate in the following, there are a number of other similar apparatus. It is claimed that with an automatic gas water heater in a house, hot water in abundance may be obtained, night or day, by simply turning a hot-water faucet at any of the fixtures where hot water is drawn.

Gas water heaters are portable and hence may be set up or removed almost as readily as any gas stove. The construction and operation of these heaters is very simple and ingenious. The exterior is usually of cast iron (see Fig. 149), while the inside consists of a long line of copper tubing, coiled inside of an iron jacket (Fig. 150).

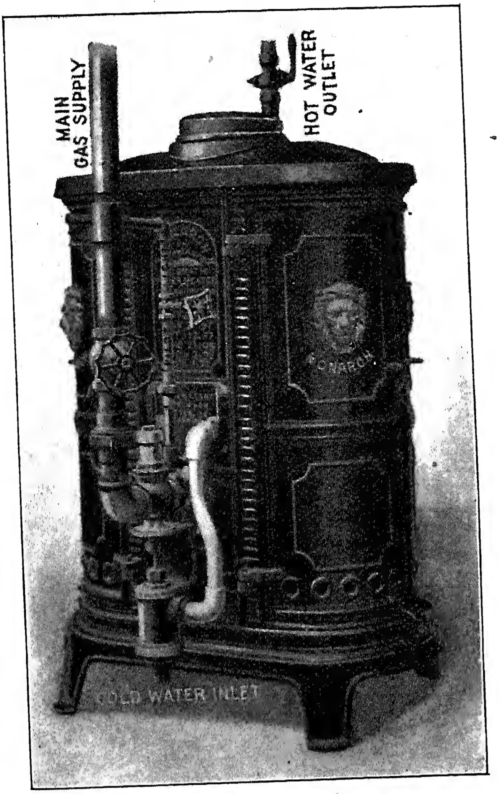


FIG. 149. View of Pittsburgh Gas Water Heater. Closed.

This copper pipe coil is placed over a special gas burner in such a manner as to utilize all the heat generated by the burning gas.

Attached to the coil at one end and to the gas burner at the other, is placed a patented graduating valve (Fig. 151), a combined water and gas valve, so constructed that the flow of water through it raises the gas valve, allowing the gas to pass into the burner to heat the water in the copper coil. The closing of the faucet shuts

off the gas the instant the water is no longer being drawn. A special feature of this automatic valve is the graduating of the flow of gas to the flow of water, so that the temperature of the water is always uniform, while economy in the use of gas is effected. The gas burner has a special pilot light, which is kept burning and is

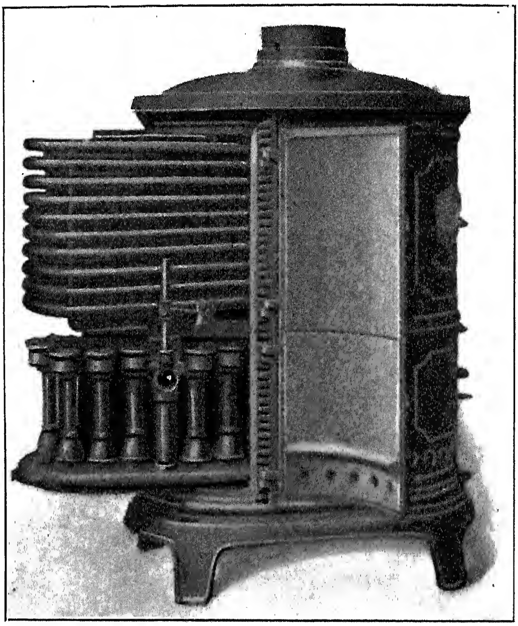


FIG. 150. View of Pittsburgh Gas Water Heater. Open.

always ready to ignite the gas from the main burner when the water turns it on.

The heater may be set up in any convenient place, but is usually located in the cellar. The required water and gas connections of proper size are made to it; either artificial or natural gas may be burned. When a hot-water faucet in the house is turned open a flow of water is started through the heater, which turns on the full gas supply, ignited by means of the pilot light, and almost instantly hot water flows at the faucet.

Coal is, of course, a cheaper fuel than gas where heat is continuously wanted, for it contains more heat units than the heat units

of a gas supply equivalent in price. Yet, where heat is wanted only intermittently and for a short period of time, gas is the cheaper fuel. A large part of the heat generated in burning coal for domestic purposes goes to waste in the chimney flue, while another part heats up the kitchen unnecessarily, to the great discomfort of its occupants.

The ordinary kitchen boiler consumes large quantities of coal to warm its contents, and during many hours it cools off without having performed useful work. This alternate heating and cooling keeps up day and night and is necessarily uneconomical.

Where large quantities of hot water are required at one time, as in residences with more than two bathrooms, the heater should be used in connection with a hot-water storage tank, otherwise it will not give satisfaction.

The Ruud automatic instantaneous gas water heater, shown in illustrations, Figs. 152 and 153, is another appliance using gas for heating water. Its distinguishing feature is the thermostat which controls the gas valve.

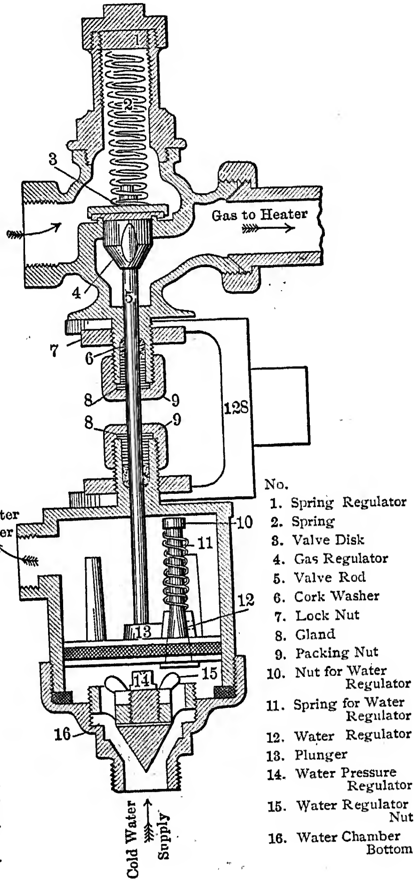


Fig. 151. Section of Automatic Gas and Water Valve for Gas Heater.

Fig. 152 shows the outside appearance of the heater and Fig. 153 its interior, showing the copper heating coil, the detachable gas burners, and the pipe connections. It consists essentially of a series of copper coils, enclosed in a cast-iron stove jacket, and of a series of powerful gas burners placed under the coils. The water-pressure valve automatically turns on the gas, which lights from a pilot light constantly kept burning, whenever a hot-water

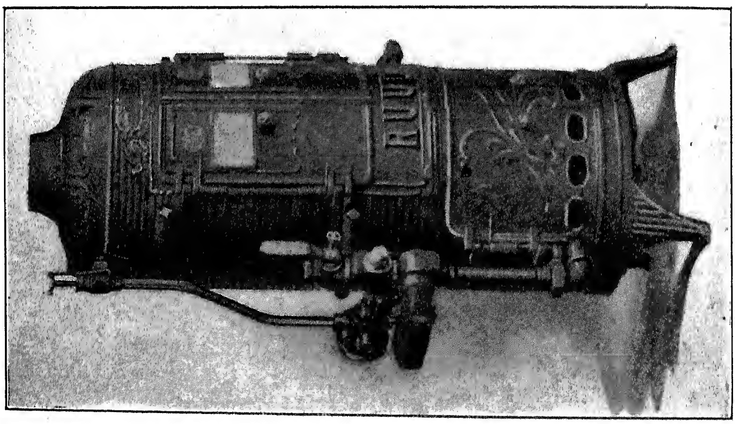


Fig. 152. View of Ruud Automatic Gas Water Heater. Closed.

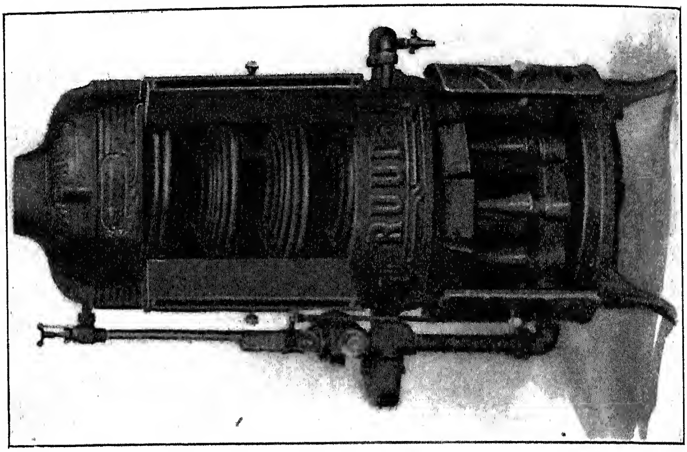


Fig. 153. View of Ruud Automatic Gas Water Heater. Open.

faucet is opened in the house, and the thermostat regulates the flow of gas to the burners and hence the temperature of the hot water obtained. The gas burns only as long as the hot-water faucet is kept open, and its closing also shuts off the gas supply (except to the pilot light).

It is claimed that with ordinary city gas, of 650 B.T.U., this heater yields 1 gallon of hot water (at 150° F.) for 1 cubic foot of gas consumed. If gas costs 80 cents per 1000, one obtains

1 gallon for $\frac{8}{100}$ cent or
$12\frac{1}{2}$ gallons for 1 cent.

If 100 gallons of hot water are used daily in a household, this means an expenditure of from $2.40 to $3.50 per month.

Where natural gas is supplied at 20 cents per 1000 cubic feet, it costs but 2 cents to heat 100 gallons.

It is claimed that the pilot light burns only about 30 cents' worth of gas per month. The gas water heater utilizes about 80 per cent of the heat of the gas, and is therefore very economical.

The Ruud heater is made in four sizes, of capacities of 3, 4, 6 and 8 gallons per minute, the No. 4 being the standard size for a house with 1 bathroom, laundry and kitchen, and the No. 8 being adapted for a house with 3 to 6 bathrooms, pantry, kitchen and laundry.

In the so-called Ruud automatic reheating system a gas heater placed in the basement or cellar is used in connection with a kitchen boiler, heated from the range. The water flows from the kitchen boiler to the gas heater; if water from the kitchen boiler is sufficiently hot, the gas is not lighted in the heater, or, rather, the opening of the hot-water faucet opens the gas valve, but the thermostat closes it again almost instantly. If the temperature of the hot water is below 140° F., the Ruud heater automatically turns on just enough gas to bring the water up to 140° F. In this way the desirable features of both are combined.

Wherever very large quantities of hot water are required, the **Ruud heater** should be used **in connection with a large storage tank** for hot water. In this case the coil used is a so-called multi-copper coil of special construction, with coils varying from $\frac{5}{8}$ inch diameter at the top to 1 inch diameter at the bottom.

For the heating of very large storage tanks, two heaters are sometimes used jointly in the so-called **Ruud Duplex system.** Sometimes the tanks contain copper steam coils and are heated in winter time by steam, while for summer use, when no steam is available, gas is utilized for warming the water. To prevent undue loss of heat from radiation, the tank should be covered in the best manner with non-conducting covering.

Material for Service and Supply Pipes.— Several **kinds of pipe** are available for the distribution of water in a house. Those in more general use are pipes of lead and of wrought iron or steel. Lead pipe may be either plain, or else tin-lined. Pipes of wrought iron and steel may be plain, or dipped into and coated with zinc (so-called galvanized pipes), or coated with asphalt or black enamel; some years ago such pipes were treated by the Bower-Barff rustless-iron process, or they were lined with cement; finally there are tin-lined and kalameined wrought-iron pipes.

Brass pipes are used quite frequently, and copper pipes to some extent, as are also pipes made of pure block tin. In the best kind of modern plumbing work annealed brass pipe, tinned on the inside, is used in preference to iron pipe, whereas lead pipe is almost entirely done away with. Other kinds not often met in actual practice are the gutta-percha, the paper, the glass-lined and the rubber-coated wrought-iron pipes. Cast-iron service pipes are used only in sizes above two inches in bore and principally for the supply of large public buildings, hotels, railroad stations, etc.

Lead Pipe.— Probably no material has been used more extensively in the past than **drawn lead pipes** for water service. Formerly, lead pipes were made by drawing the material over dies. It is now usual to melt the lead in a suitable vessel and to pour it into a kind of hydraulic press, wherein the lead is first allowed to cool. It is then forced through an aperture in the bottom of the press cylinder, corresponding in size to the desired outer diameter of the pipe, and over an iron core of the desired inner pipe diameter. The finished pipe is rolled up in coils of various lengths, depending upon the capacity of the hydraulic press.

The chief advantages of lead pipe are the facility with which it is handled and bent to suit all positions, the easiness with which connections and repairs are made, the comparatively small number

of joints required, and its cheapness and durability. Among disadvantages I mention the fact that, owing to its weight, lead pipe is apt to sag unless the pipe is carefully and continuously supported, especially so on horizontal runs, and more so with hot- than with cold-water pipes, owing to the expansion of the metal due to changes of temperature. Lead pipe is, moreover, very easily injured by external pressure, by blows from a hammer, or by the driving of nails into it, as well as by the gnawing of rats.

The chief **objection to lead** as a material for water pipes is a sanitary one. It arises from the fact that certain waters, notably soft waters and those containing much oxygen, attack the lead vigorously and dissolve a sufficient amount to cause dangerous lead poisoning. As this is a chemical rather than a purely engineering question, I quote the recent opinion of a chemist, the late Prof. W. Ripley Nichols of the Massachusetts Institute of Technology, an authority on the subject.

> "Various waters act very differently upon lead, some corroding it rapidly, others to a very slight extent only, under similar circumstances. The cause of the corrosion is to be sought in the dissolved oxygen, of which all water contains more or less, and in certain saline substances, the presence of which determines a more violent action. It is generally felt, for instance, that the presence of nitrates, nitrites and ammoniacal salts increases the action of the water on lead, while carbonates, sulphates and notably phosphates hinder such action."

This question is of the greatest moment in the case of an intermittent supply, in which the pipes are left empty for many hours, in which case the oxygen of the air probably causes a much stronger and quicker corrosion of the pipe. Where pipes are constantly kept full of water — and this is the system almost universally adopted in American cities, as has been referred to in the introduction to this chapter — the corrosion takes place largely when the pipes are first put into use, while soon afterward they become covered with a white protective coating, which is not easily dissolved by the water and prevents any injurious contaminating effects. The origin of this white lining, which upon analysis is found to consist largely of carbonate of lead, is explained by chemists as follows: The oxide of lead, formed by the chemical action of the oxygen contained in the water upon the lead, combines after a while with the carbonic acid in the water or with the bicarbonate

which it contains, to form carbonate of lead, which adheres as an insoluble coating to the inside of pipes. After the pipes become coated in this manner, the corrosive action practically ceases.

Some doubt remains, however, as to whether the action of a water on lead ever ceases entirely. It is, therefore, much to be recommended, as a measure of safety when drawing water from lead pipes for drinking or culinary purposes, always to let a sufficient amount pass through the pipes and run to waste. This rule should be particularly observed when drawing water in the morning after it has stood all night in lead pipes. In the case of newly-put-in lead pipes this precaution should never be neglected.

Some chemists recommend to be particularly cautious in the case of lead pipes used for hot water, and advise never to use for drinking or for cooking purposes water which has stood hot in the pipes. In the case of cold water there is also, undoubtedly, some danger in using lead for suction pipes in cisterns containing soft rain water or in wells with moderately hard water. In both cases a considerable length of the pipes may be exposed to air and water alternately, owing to fluctuations in the level of the water in both wells and cisterns, and the corrosion may be a very rapid one. Very hard waters do not act much on lead provided the pipes are kept full, but even in their case lead pipes should not be employed for suction pipes from wells.

After a careful review of the testimony of chemists, I think it may be safely stated that the danger from using lead pipes for water distribution in houses has been somewhat exaggerated, and that unnecessary alarm and prejudice was created in many cases. With a moderately hard water, and with proper precautions in its use, no danger, in my judgment, need be apprehended from the use of lead pipes. As a matter of precaution against external corrosion lead pipes should not be laid in damp soil containing much lime, nor should they come in contact with cement.

Coated Lead Pipes.— Various means have, from time to time, been suggested to cover the inside of lead pipes with a **protective, insoluble and durable coating.** The use of paraffine has been proposed for this purpose. Professor Wolffhügel mentions the application of a solution of sulphide of potassium or sodium, which

causes the pipes to be covered with a film of insoluble sulphide of lead.

Another method of chemical protection consists in filling lead pipes with a weak solution of phosphate of soda, which soon combines with the lead to form a protective coating of insoluble phosphate of lead.

Tin-lined Lead Pipe.—The best mechanical lining for lead pipes of which I have knowledge is tin. **Tin-lined lead pipes,** sometimes called lead-encased tin pipes, are now in extensive use in the United States, but particularly so in Germany, where this kind of pipe is called "Mantelrohr," and has largely displaced the ordinary lead pipe. A tin lining, it is true, is also acted upon by water, but only very slowly, and the substances formed are insoluble and harmless. Exposed to the air, tin oxidizes very slowly at ordinary temperatures. The name given to the pipe is to some extent misleading, for it is not a lead pipe coated with a mere thin lining of tin. Such pipes have been sometimes sold, but they are not a satisfactory nor a durable article.

In a well-made tin-lined pipe the tin lining forms a continuous independent and uniformly thick tube within the lead pipe. The tin should not be forced upon the lead by heat, as an alloy may then be formed, which would render the lining objectionable. The two pipes should simply be joined under a strong pressure. Such tin-lined pipes can be as easily handled as lead pipes. Owing to their supposed greater strength they were at first made somewhat lighter than plain lead pipes, but it is advisable to use tin-lined pipes of the same weight as ordinary pipes. In their outside appearance they do not differ from ordinary lead pipes except by having put on them, in the course of manufacture, as a mark by which to distinguish them, a number of slightly raised longitudinal ribs or corrugations.

Such pipe is more expensive in first cost than lead pipe, and it also requires greater care in making the joints. A careless workman, in wiping a joint in the usual manner, is very apt to scrape off the protective tin lining, thus exposing portions of the lead pipe. It is a fact established by scientific investigation that lead is more easily corroded by water in the presence of other metals, such as iron, zinc, or tin, and this is explained as being caused by a galvanic

action which, it is thought, takes place when two metals are placed side by side in water. To avoid the danger of imperfect joints, special tinned brass ferrules or couplings and Tee branches are sold by the manufacturers with the tin-lined lead pipe, but, so far as my observation goes, they are not used much.

Block-tin Pipes.— Pipes made of **pure block tin** in the same manner as drawn lead pipes have been used in houses to a limited extent. From a sanitary point of view no objection can be raised against them. They are, however, more difficult to handle and are very much more expensive than tin-lined pipes, without offering corresponding advantages, except in the case of suction pipes for wells and cisterns, for which purpose they are superior to the lead and the lead-encased tin pipes. The exterior of the latter, it should be remembered, if used in wells or cisterns, is apt to contaminate the water. Some chemists warn against the use of block-tin or tin-lined pipes for hot-water distribution, claiming that tin is very sensitive to heat. It is also best not to use block-tin pipes in moist ground, where they are often corroded more rapidly than plain lead or tin-lined lead pipe.

Wrought-iron and Steel Pipes.— Ordinary **wrought-iron and steel service pipes** are manufactured at the rolling mills from wrought-iron bars bent up by means of machines to a circular shape. In the small sizes the ends are butted against each other and welded together; in pipes of larger diameter the longitudinal seams are lapped over. Before leaving the works all pipes are tested with a pressure varying from 300 to 500 and even more pounds per square inch.

Plain wrought-iron pipes would be well adapted for carrying water but for the fact that they are perishable, being rapidly oxidized by the action of water, especially of soft water charged with much oxygen. They are particularly objectionable for an intermittent system of water distribution, as they quickly rust internally when exposed to the air in a wet or moist condition. They are also easily corroded externally when laid in a wet or damp soil, or in soil impregnated with acids or chemical refuse; they are likewise much attacked if laid under water, as in wells or cisterns, or if run through rooms containing an atmosphere highly saturated with moisture.

While oxide of iron, commonly known as iron rust, is unobjec-

tionable from a sanitary point of view, the taste of the water becomes unpleasant, it is thereby rendered unfit for culinary purposes, and there is besides the great drawback that linen is marked by yellow stains due to the iron rust, which are not easily removed. In the case of pipes of smaller size obstructions frequently occur owing to the accumulation of rust, which may seriously interfere with the free flow of water.

The advantages of wrought-iron service pipes from an engineering point of view, on the other hand, are many, chiefly amongst them being the strength of the pipe in resisting high interior pressure, as well as in not being easily hurt by blows from the outside, and not being liable to damage by careless driving of nails, etc. Wrought-iron pipes may be carried horizontally in pipe hangers and do not require continuous supports to prevent sagging; they are also quickly and permanently put together by screw joints. Add to this the cheapness of the smaller sizes, and it may be understood why many claim that wrought-iron pipes are superior to lead pipes.

Wrought-iron and steel pipes are made in all sizes, from ¼ inch upward to 20 inches, and in three grades or weights, known respectively as the standard, the extra-strong and the double extra-strong pipe. In the two heaviest grades the extra thickness is put on the inside and thus decreases the inside diameter, whereas the outside diameter remains the same as that of standard pipes.

During the past decade the pipe mills have manufactured largely steel pipes, although these are sold as "wrought-iron" pipe. It is very difficult, even for an expert, to distinguish between the two kinds by a mere inspection. There are only two ways to tell whether a pipe is of steel or of genuine wrought-iron: one is to submit a sample piece of the pipe to a chemical analysis, the other is to cut and thread the pipe in a hand-cutting and threading machine. It will be found that the steel pipe contains more carbon, and that it cuts and threads harder.

It is well known that steel corrodes quicker than wrought iron when exposed to the weather, hence arose some prejudice against the steel pipe. As a matter of fact, steel pipe is as serviceable as wrought iron, except possibly for vent pipes, and for peculiar conditions of the water. If a specification contemplates the use of wrought-iron pipe, it is advisable to call for "genuine" wrought-

iron pipe; sometimes the name of a manufacturer is used, such as "Byers" wrought-iron pipe. Steel pipes are manufactured more cheaply than wrought-iron pipes, hence one has to pay a higher price for the genuine wrought-iron pipe.

There is some danger, when wrought-iron or steel pipes are used concealed in buildings, of electrolytic action taking place, by which both kinds of pipes become rapidly pitted, honeycombed or corroded.

It is very desirable that more information should be available about the relative advantages of steel and wrought-iron pipes, and in particular about their relative corrosion. (See Chap. VII.)

Galvanized Wrought-iron Pipes.— The many points of advantage enumerated have led to the search for some permanent protecting coating, which would render wrought-iron and steel pipes adapted to all uses and for all situations. **Zinc-coated or galvanized pipes** have been used extensively for a number of years, and the opinions differ greatly as to their merits. While some assert that galvanized wrought-iron pipe makes an excellent service pipe, and that it is, next to lead, the most suitable material, others condemn it altogether. Very much probably depends, as in the case of lead pipes, on the chemical and physical properties of each particular sample of water.

With ordinary water such pipe may be entirely safe to use, provided the pipes are not left empty at any time. In case the galvanizing is imperfectly done, the smaller sizes are apt to clog. Some assert that galvanized wrought-iron pipes should not be used for hot water, probably owing to the prevailing opinion that increase of temperature increases the corrosive action of the water. Much will depend, of course, upon the care with which the coating is applied.

Wrought-iron service pipes are galvanized by first cleaning them thoroughly by means of diluted acid solutions, and then immersing them into a bath of melted zinc. The latter does not merely form a protective surface lining, but is said to penetrate the iron more or less.

Authorities differ as to the corrosive action of water on zinc. Some claim that the zinc coating, if properly applied, will last for many years. Others, whose opinion entitles them to equal consideration, state that corrosion begins as soon as water fills the pipe, that at first the zinc only is attacked, but that finally the protective

film of zinc will more or less disappear, leaving the iron exposed to rust. From a health point of view galvanized pipes are not very objectionable, for, although the water passing through such pipes usually dissolves salts of zinc, which are poisonous, and also carries some in suspension, the amount is not such as to cause any serious harm.

Tin-lined Wrought-iron Pipe. — Tin-lined wrought-iron pipes are unobjectionable from a sanitary point of view; in fact, they keep the water in an excellent condition of purity, but it is rather difficult to apply the lining in such a manner as to be permanent. If only a small surface of the plain iron is left exposed, corrosion goes on more intensely in the case of these, as also with zinced pipes, than if the pipes were left entirely unprotected. This may be due to a galvanic action caused by water coming in contact with the two different metals. Tin-lined wrought-iron pipes should be connected by means of tinned-brass screw ferrules.

Asphalted Wrought-iron Pipe. — Asphalted wrought-iron pipes have also been used, and the only objection to them, that I know of, is that the water standing in the pipes acquires an objectionable taste of tar, which continues for a long time after the pipes are put in use. This can be easily remedied, however, with new pipes by allowing the water to run to waste when drawing it for drinking or cooking purposes. It is quite important, in order to secure a good permanent asphalt coating, that the pipes be dipped into a bath of asphalt of proper consistency after being thoroughly heated. If the asphalt is applied cold, it may soon be washed off and carried in suspension in the water. For conveyance of hot water the asphalted wrought-iron pipe is not well suited, as the high temperature would increase the tendency of dissolving the asphalt coating.

Enameled Wrought-iron Pipe. — Enameled wrought-iron pipes are more or less expensive, according to the preparation used to protect the iron, which ranges from an ordinary coal tar or asphalt with linseed oil or other bituminous varnish to a high paraffine enamel. Enameled pipe is excellently adapted for pipes laid in the ground, and for carrying water from a distant spring to a house; also for suction pipes in cisterns and wells, and for cold-water service pipes in houses. Care should be taken, in making joints in this kind of pipe, that the threads and pipe ends are thoroughly

coated with the liquid enamel, sold by the manufacturers of such pipe, otherwise the joints, having the bright iron exposed, will soon commence to rust.

Rubber-coated and Glass-lined Wrought-iron Pipe. — I have no experience in the use of **rubber-coated iron pipes,** and do not know of their being used at the present day, to any extent. Regarding **glass-lined iron pipes,** they would, obviously, make a pipe for house service excellently fit for keeping the water pure. But they are very expensive, fragile and easily broken, and it is difficult to run them and to make the joints properly, hence they are seldom employed; in fact, I believe their manufacture has recently been given up.

Cement-lined Wrought-iron Pipe. — Another method of protecting wrought-iron pipes against corrosion is the lining of the inside of the pipes with cement. **Cement-lined wrought-iron service pipe** has been in use for many years, principally in some New England towns. I am not sufficiently familiar with the use of such pipe to speak with authority of its merits or demerits. From a description, I learn that the process adopted for lining such pipes is as follows: The sizes used are $\frac{3}{4}$ inch, 1 inch and $1\frac{1}{4}$ inches, the lining having a thickness of $\frac{1}{8}$ inch, thus reducing the clear bore of the pipe to $\frac{1}{2}$, $\frac{3}{4}$ and 1 inch respectively. A mixture of Portland with some Rosendale cement is used for the lining. This mixture is injected into the pipe by means of a special press, and two cones of the diameter of the finished bore are then drawn through the pipes, pressing the cement against its sides. The cement is then allowed time to rest, and finally a liquid grout is poured through the pipe to fill any imperfections in the first coating.

It is, of course, necessary in using the cement-lined pipe to employ malleable-iron fittings which are suitably protected against corrosion. It is common to use galvanized- or asphalted-iron or else brass fittings. Care should be observed to protect the ends of service pipes, inserted into fittings. Here, at the pipe ends, and in couplings, there is often trouble experienced from rusting.

From a sanitary point of view such cement-lined pipe appears to me entirely unobjectionable, except that it may have some effect in slightly increasing the hardness of the water, at least when water is first turned into the pipes. If the process is carefully carried out

there seems to be no reason why such lining should not efficiently protect wrought iron from corrosion. But, where such pipe requires much handling and transportation, the greatest care is, in my judgment, needed to prevent the hardened cement from breaking off from the sides of the pipe, causing their quick rusting and obstructions and choking of pipes.

Rustless Wrought-iron Pipe. — Another protective treatment for wrought-iron pipe, introduced about twenty years ago, was the one known as the **Bower-Barff or rustless-iron process.** By this process the natural surface of wrought iron or steel was converted into a magnetic oxide of iron which, from experience, was known to withstand the worst possible exposure to air or to fresh water or saline solutions. The formation of magnetic oxide of iron was accomplished by subjecting the iron in a specially built furnace to the action of superheated steam. In this process no foreign material, paint, chemical or alloy was applied to the metal. The coating is perfectly innocuous, and such rustless pipes may be heated to redness and then plunged into cold water without being injured. Such rustless pipes were also claimed to be well adapted for carrying hot water. The Bower-Barff process was a rather expensive one and in recent years it has not been applied to water pipes to any extent.

Pipes treated by means of this process are best joined by using only oil at the threads, which, after a while, hardens and sets, making a tight joint, while, if a mixture of red and white lead is applied to the threads and fittings, there is a slight danger of water dissolving some of the lead, which unavoidably protrudes at the inside of the joints.

Kalameined Pipe.—I should, perhaps, say a word about the so-called "Kalamein" pipe, a pipe coated in a manner similar to galvanized-iron pipes. The pipe was made by compounding a mixture of lead, tin, nickel and zinc, and bringing it in contact with wrought-iron pipe, which has been previously cleaned and freed of scales, grease or dirt, by dipping it into a bath. It was claimed that the melted alloy penetrated the body of the iron, and became thoroughly combined with it. I have never used this pipe; it is comparatively little known and I find scarcely any reliable information, but only some very contradictory opinions, concerning it.

Lead-lined Wrought-iron Pipe.— This pipe is made in much the same manner as the tin-lined wrought-iron pipe, and combines the stiffness of a wrought-iron pipe with the smoothness of the interior of a lead pipe. But for its high cost it would probably be used to a larger extent than is the case at present. In special situations this pipe fulfills its object in a satisfactory manner, as, for instance, for the vent-pipe extensions of pipes in chemical laboratories, where wrought- and cast-iron pipe would be too quickly attacked by the fumes of chemicals. For supply pipes, too, it is in use to a limited extent, although the difficulty of making the joints renders it more troublesome to handle. A large line of **lead-lined wrought-iron fittings** is also manufactured.

Brass and Copper Pipes.— It remains to speak of **brass** and of **copper pipes.** Both of these should, if used for the conveyance of drinking-water, be tinned on the inside, as water seriously attacks any exposed brass as well as copper, and the salts of copper, oxides as well as carbonates, carried in the water in suspension or in solution, are poisonous. Small seamless copper pipes are drawn to size in dies, being thus made much stronger than if made by rolling up sheet copper and brazing the edges together. Copper is very ductile and has a considerable tenacity, but it should be pure, for any foreign admixture renders it weak. In tinning copper pipes, these should first be thoroughly cleaned and brightened, then washed with a solution of sal ammoniac or of zinc in muriatic acid, which leaves a bright metallic surface free from oxide or greasy matter.

Seamless brass tubes are made by drawing the metal over a mandril. If used for hot-water purposes, and if it is made sure that no hot water from such pipes is ever drawn for cooking, the tin lining may be omitted from brass pipes. Copper pipes are not often used as they are very expensive and require special care and skill in running them. Brass pipes are nickel-plated and polished wherever placed in sight in conspicuous positions, or else plain finished or tinned brass pipe is used, but this should be varnished to prevent tarnishing.

Faucets and Shut-offs.— **Shut-offs and faucets** are special devices governing the flow of water through pipes. Broadly speaking, we may distinguish in the water-pipe system of a house **three kinds**

of shut-offs: **first,** taps usually placed at the end of a line of pipe, so as to control the flow of water from the pipe at or into a plumbing fixture, which appliances are usually known as bibs, cocks or faucets; **second,** fittings placed in the line of a main pipe or of a branch, so as to control, shut off or turn on or regulate the flow of water **through** said line of pipe, which fittings are commonly known as stopcocks or shut-offs, and which, according to their special construction, may be either stopcocks or else stop valves, both with and without small waste or drip openings; and **third,** cocks which are operated either by a ball or else by a float, usually called ball cocks, and used in large water tanks and in the smaller flushing cisterns to close the supply pipe when the tank becomes filled, and to open it again when the water level in the tank falls.

Each class of cocks, no matter of what special shape or make, may again be subdivided into two kinds, according to the principle involved in their special construction, namely, into **ground** bibs, or, as they are sometimes termed, plug taps, and **compression** bibs or faucets. We distinguish, therefore, between ground-key and compression faucets, ground-key and compression stopcocks, ground-key and compression ball cocks.

Ground-key Bibs. — The **ground bibs** (Fig. 154) are made entirely of metal, usually of brass; no washer or soft packing of any kind is required in their operation. In such fittings a plug or key is used, of slightly tapering form, which has a hole of nearly the bore of the pipe, and which if turned in a casting, which forms the waterway, so that this opening is in line with the opening in the casting, allows the water to run, while if turned at right angles to the previous direction it completely stops the flow. If partly turned the flow is cut off somewhat. The key or plug is made tapering, so as to allow for tightening up by means of a brass set screw if it should leak.

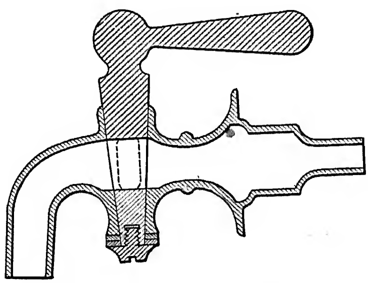


FIG. 154. Section of Ground-key Faucet.

The ground-key work is objectionable for faucets as well as ball cocks in the case of gritty waters, which have much mineral sedi-

ment in suspension. In this case small particles of sand may become lodged between the brass key and its seat, and the frequent handling and turning of the cock soon causes the plug to be cut, to wear out, and to become defective, and as a consequence such faucets and ball cocks continually leak. Repairs of worn-out fittings are

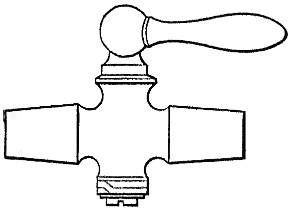


FIG. 155a.

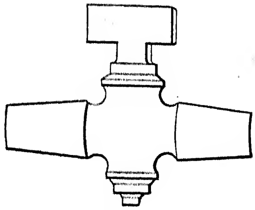


FIG. 155b.

Lever Handle and T Handle Ground-key Stopcocks.

difficult and expensive, and it usually becomes necessary to replace a dripping cock by a new one.

In case of **stopcocks** for the control of the flow of water through pipes (Fig. 155 a and b), ground plugs are not so objectionable because they are not often turned. But, if used, it is far better to

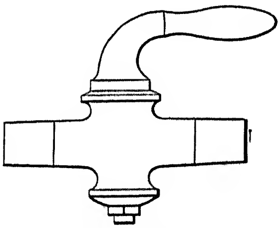


FIG. 156a.

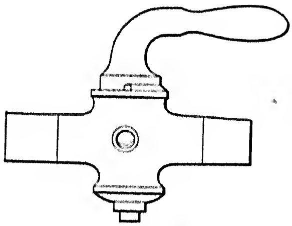


FIG. 156b.

Round-way Stopcock and Stop-and-Waste Cock.

employ the so-called **round-way** stopcock (Fig. 156 a and b), which, on being opened, gives a full-bore stream, and hence gives a greater discharge from a line of pipe than where ordinary stop-cocks are used. A second and equally important objection to "ground" bibs is that, if they are turned, the flow of water is so suddenly and quickly stopped as to cause a severe shock — technically called "water-hammer" — which strains the pipes sometimes so much that they eventually burst after being weakened for some time. It is, therefore, a safe rule not to use "ground" faucets,

wherever the pressure of water in the pipes is great. This objection does not refer to stopcocks, as they are not often turned, yet, even in their case, "compression" stops or stop valves of brass are much to be preferred whenever the pressure in the supply pipes is great.

Compression Bibs.— In the "compression" bibs both objections are successfully overcome.

In **these bibs** the construction is such that the water is made to pass through a pierced diaphragm in the bib (Fig. 157), and the flow is checked by tightly screwing down a compressible washer,

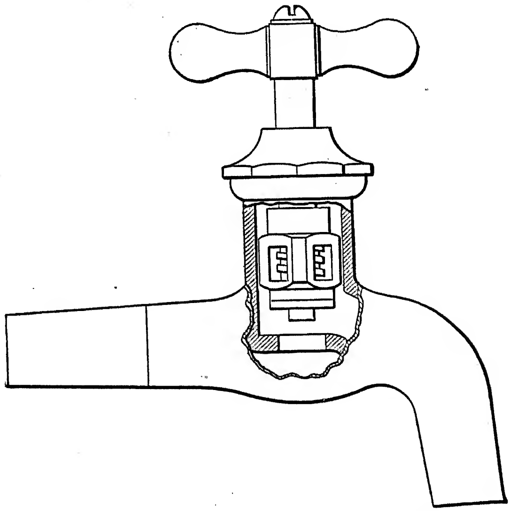


FIG. 157. Section of Compression Bib.

either of soft leather or of rubber, attached to a piston without perforation, upon the usually horizontal diaphragm. If the piston with the washer is raised from the seat more or less, a flow of water occurs, the force of which can thus be controlled. The washer is either attached to the spindle so as to revolve with it, or it moves up and down straight where the spindle has a screw operating inside of the plug. The flow of water is, therefore, *gradually* cut off, and when finally checked does not cause any severe water hammer or strain, hence such faucets are much more generally used. In case they become leaky it is owing to the wearing out of the leather washer, and this is easily replaced without

requiring any great skill. A word of warning with regard to compression work may not seem out of place. Whenever such bibs commence to leak, avoid checking the leak by screwing the piston down too tight. This causes the quick wearing out of the screw threads, and, if once the latter become damaged, the faucet becomes worthless. The proper remedy is to at once replace a defective washer by a fresh one.

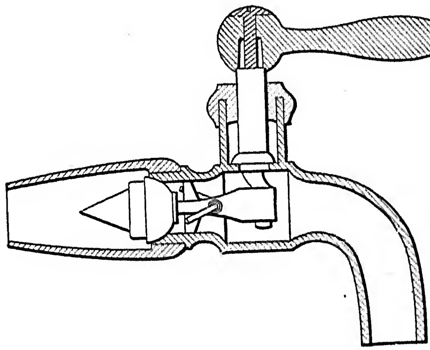


FIG. 158. Section of Fuller Faucet.

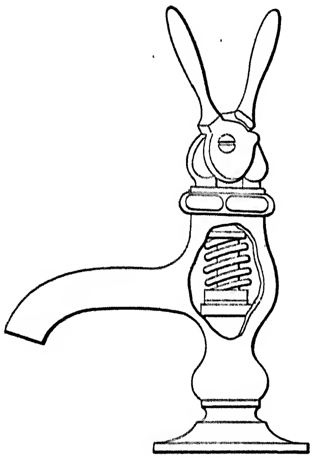


FIG. 159. Section of Self-closing Faucet.

Fuller Bibs. — There is an endless variety of compression cocks, the majority being operated by means of a piston and spindle, worked by a screw, and closing against the water pressure.

The so-called **Fuller compression work** (Fig. 158) makes an exception to this, for it has a rubber plug or valve, which closes with, instead of against, the water pressure, and is operated by a lever and eccentric instead of a screw movement. This latter kind is well adapted for use, is of excellent construction and make, and is easily repaired. For service pipes with very high pressure, however, it is better to use ordinary "screw-down" compression work, to avoid the water hammer which occurs with these faucets as much as with the ground-key bibs.

Self-closing Bibs. — Besides the ground bibs and the compression cocks which close by hand operation, I ought to mention the so-called **self-closing bibs** (Fig. 159), of which there are a great many different kinds in the market. Many of these are operated

by a strong spring which causes the closing of the bib as soon as the handle is released. Some close with, others against, the water pressure. These latter depend upon a spring to keep them tight, and are harder to open. If the tension of the spring relaxes in course of time they may leak. The objection which was mentioned

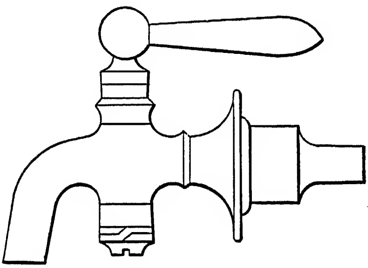


FIG. 160a.

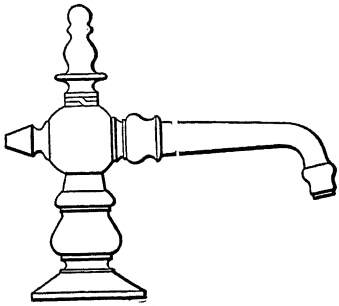


FIG. 160b.

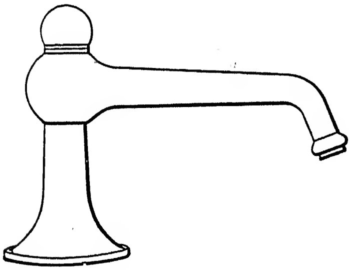


FIG. 160c.

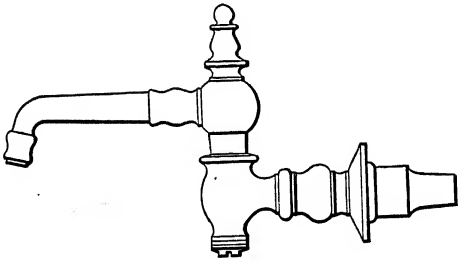


FIG. 160d.

A Group of Ground-key Faucets.

in the case of ground-key bibs is true of most self-closing faucets, except a few which are slow-closing, namely, the liability of straining a pipe system by the too sudden checking of the flow of water.

Self-closing bibs, however, perform a useful function in public places, hotels, railroad depots, market-houses, schools, and at public drinking fountains, in preventing a reckless waste of water, and also, occasionally, in preventing serious damage to ceilings and plastering caused by accidental overflows. For private residences their use is not recommended, except where the prevention of water waste is an important consideration, as when the service pipe is metered. They are somewhat inconvenient in use, necessitating

the holding of the bib handle for some length of time, until sufficient water is drawn, and often requiring a strong pressure to counteract the tendency of the spring to close the bib. On hot-water pipes, self-closing faucets should not be used, because, if the circulation is at all active, the lever handle may become too hot to touch.

Wherever self-closing or ground-key bibs are used it is a good precaution to adopt air chambers at the end of branch pipes in order to counteract the effect of water hammer, but, in adopting this safeguard, it should be borne in mind that air vessels are seldom effective, unless charged with air at frequent intervals. Many self-closing bibs are unreliable and not very durable.

The illustrations, Figs. 160, 161, 162, 163, exhibit a number of faucets, of the four types mentioned, as they are made for use with different plumbing fixtures.

Types of Faucets. — To describe minutely all the **various forms of cocks** illustrated and by means of which water is drawn at the different fixtures in a house would lead me too far, and a few minutes' study of the illustrations in catalogues of plumbers' brass goods will explain all I would have to say far better than I can, but the above illustrations will give a fair idea of the large variety in styles.

For wash basins and also for double pantry sinks a swing cock is very much used which is technically known as a "ground-key basin cock." This has a movable outlet tube, swinging around a vertical axis, and is so constructed that, when the tube is turned over the basin, the cock is open, permitting the water to flow into the basin. By turning the tube to either side the water is shut off. Such faucets are very convenient and were at one time used quite extensively, but they do not last long in the case of water containing much gritty sediment, and soon commence to wear out and drip. The compression and self-closing basin cocks are now largely preferred. In both kinds the outlet tube remains stationary over the basin edge, and the water is turned on or shut off, generally, by turning a handle, but sometimes by pressing two handles together. There is also a basin compression bib made which opens when swung over the basin and closes by being turned.

Bath tubs are sometimes supplied by two single bath bibs, which may be either of the ground-key or the compression pattern and

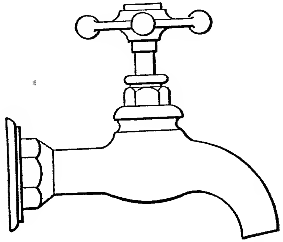


Fig. 161a.

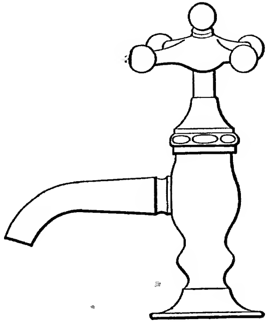


Fig. 161b.

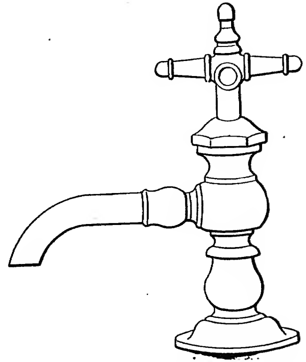


Fig. 161c.

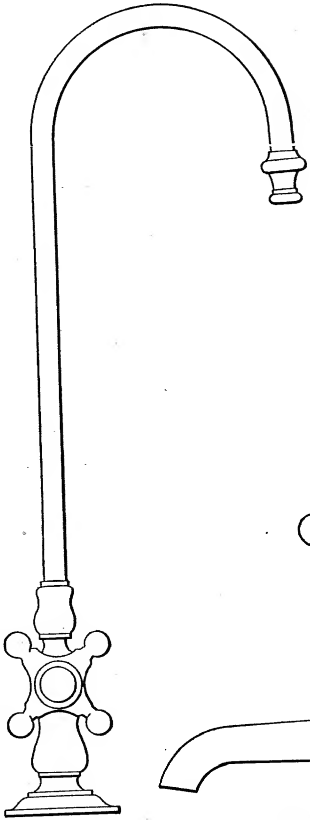


Fig. 161f.

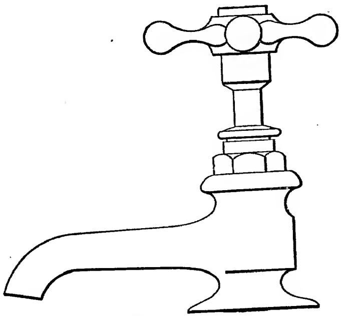


Fig. 161d.

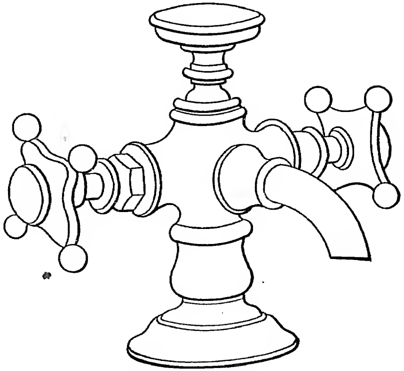


Fig. 161e.

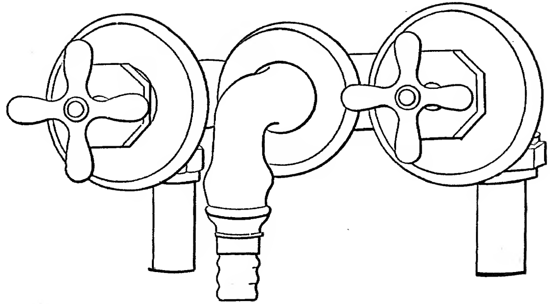


Fig. 161g.

A Group of Compression Faucets.

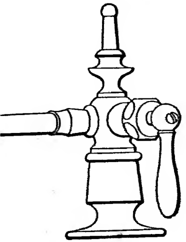


FIG. 162a.

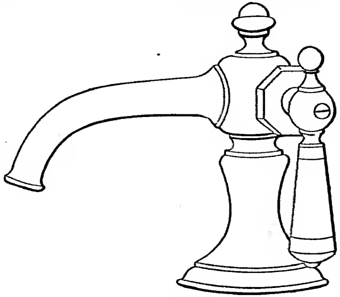


FIG. 162h.

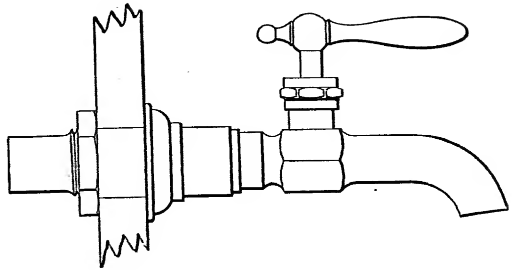


FIG. 162b.

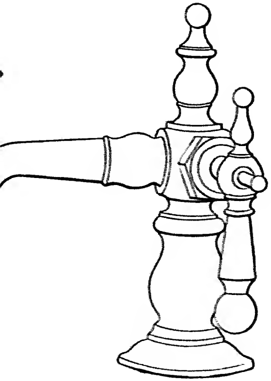


FIG. 162d.

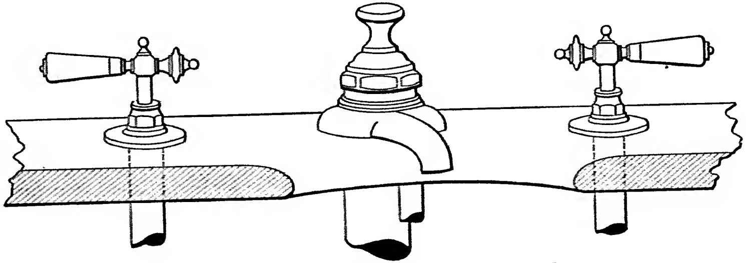


FIG. 162e.

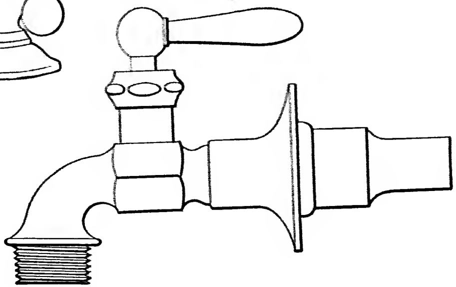


FIG. 162c.

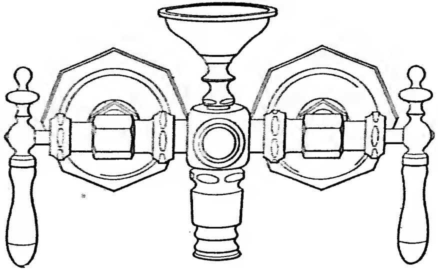


FIG. 162g.

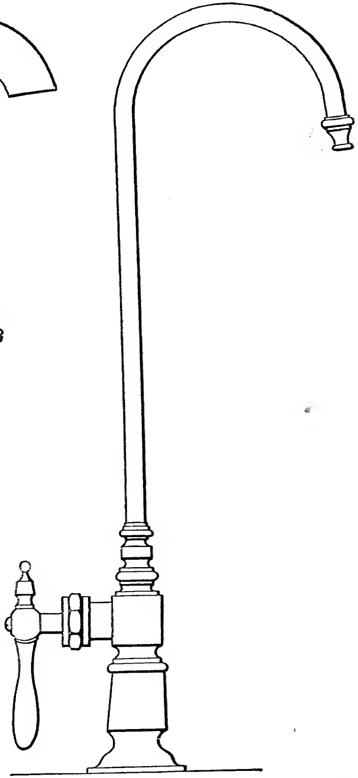
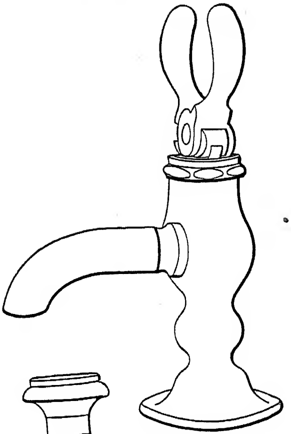


FIG. 162f.

A Group of Fuller Compression Faucets.



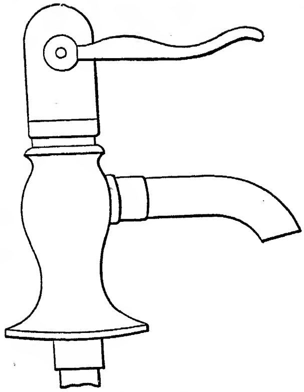


Fig. 163h.

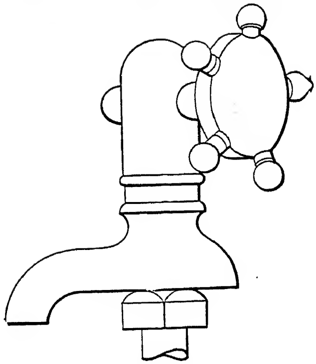


Fig. 163f.

Fig. 163a.

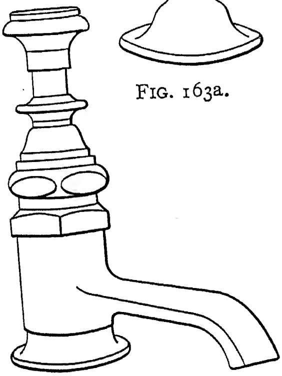


Fig. 163b.

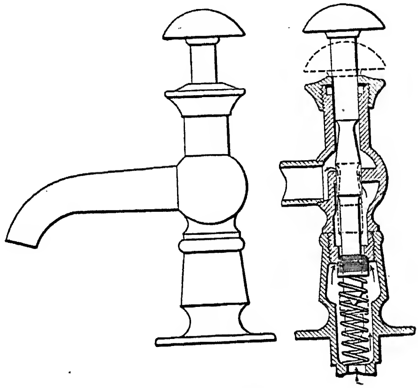


Fig. 163k.

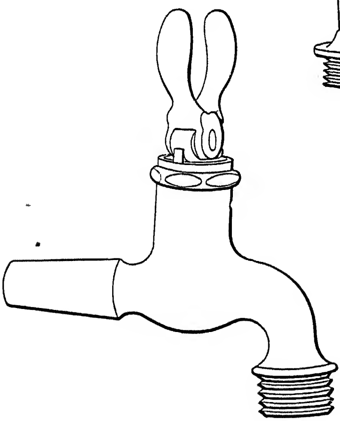
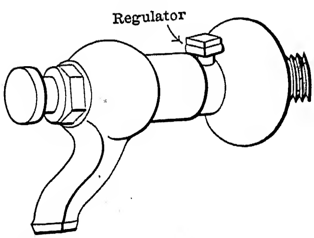


Fig. 163d.



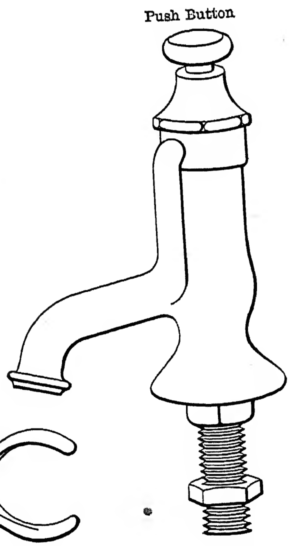


Fig. 163c.

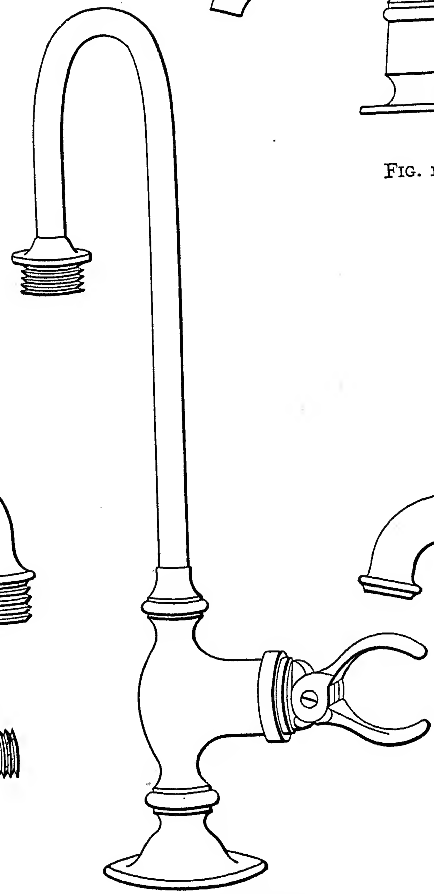


Fig. 163g.

which have a short spout turned downward, so as to deliver water into the tub. Such bibs are designated as plain, if made so as to be soldered to lead pipe, or else as flange and thimble bibs, the latter having a brass or plated thimble, which is soldered to the lead pipe, while the bib is screwed into the thimble, making a neatly finished job, or finally as screwed bibs, for attaching to wrought-iron or brass pipes.

Within the last few years the custom has become more general of supplying bath tubs by means of double bath-cocks, or combination cocks with two handles and with a single outlet nozzle, through which either cold or hot, or mixed water is delivered. The outlet tube is generally provided with a thread, for attaching a hose nozzle, the other end of the hose having a rose shower, which takes the place of the old-fashioned overhead fixed shower. Such mixing nozzles are quite convenient and do away largely with the steam-vapor nuisance.

Bath tubs are also supplied at or near the bottom of the tub by means of a bell or fan supply. Such an arrangement prevents the damage so frequently done to enameled or copper tubs when water is drawn into pitchers by careless servants, and it also avoids the noise occasioned by filling a tub from bibs placed near the top. On sanitary grounds, however, the devices for filling bath tubs at the bottom cannot be recommended, for the opening of a faucet on a floor below may cause the dirty water to be drawn from the bath tub into the supply pipe by siphonic action and thus result in the contamination of the water supply. A check valve would prevent this, but it cannot be relied upon to work forever, hence it is safer to supply a bath tub from the top of the tub.

Concerning faucets in general, it may be well to warn against the many cheap varieties made to meet the existing sharp competition. It will be best and most economical in the end to buy only bibs of superior material and workmanship, even if they cost more.

For kitchen sinks and wash-trays similar bibs as those for bath tubs are used, and they may be either of the compression or ground-key variety. For sinks the handles are placed on top, and for wash tubs on the side, of the bib. It has been usual, in the case of butler's-pantry sinks, to use tall and upright faucets having a

long tube turned over and downward at the top, thus enabling servants to put a pitcher underneath for filling, but the drawback to these is that the gooseneck becomes loose and leaky in the joints, and for this reason the regular style of sink faucet is far preferable.

Materials for Faucets and Finish. — So much about the kinds of bibs. As to the **material,** different makers employ slightly different alloys. Common brass is ordinarily used, but for the best work phosphor-bronze, steam metal and gun metal, the latter particularly for stop valves, are adopted. Stopcocks are usually brass-finished, and faucets for sinks, bowls or tubs are ordinarily finished and polished, or, where the slight difference in expense is no objection, it is usual to cover and brighten them with either a silver or nickel plating. There is some difference in opinion as to which of these is preferable.

The plating by either process, if carelessly or poorly done, will not last long, particularly if servants do not observe care in cleaning the polished faucets. As a rule, I find it is easier to obtain from the makers a good and lasting nickel plating, but excellent-looking silver plating may be obtained, done especially to order and guaranteed to last many years. Of late years, faucets of a new alloy, called "silver metal" or white metal, have been introduced. If well finished and polished, such a faucet looks fully as handsome as a nickel-plated one, and has the advantage of not becoming worn off by frequent rubbing.

Valves. — Ground-key and compression stopcocks have been commonly used in the past in pipe lines to control the flow of water. While they fulfill their purpose tolerably well where the pipes are small, **it is nowadays considered** the **better practice to use valves** on all large distributing lines and on the main supply service.

There are two kinds of valves, namely, the **gate valve** (Fig. 164) and the **globe valve** (illustrated in section in Fig. 165). The chief advantage of the gate valve over the globe valve is that it gives a fullsized water way when entirely open. The only advantage of globe valves is that in case of gritty waters the soft disk can be quickly and economically replaced when worn out. It is obvious that a globe valve is otherwise inferior to the gate valve because it necessarily restricts the flow, and causes greater friction because the water passage is not straight. A further objection is that the

body of the valve is so shaped that it retains some water and hence does not permit of the complete draining of a pipe line.

There is, however, one special form of globe valve with disk and valve seat which gives almost as unrestricted a flow of water as the gate valve. This is the **angle valve,** which has its two open-

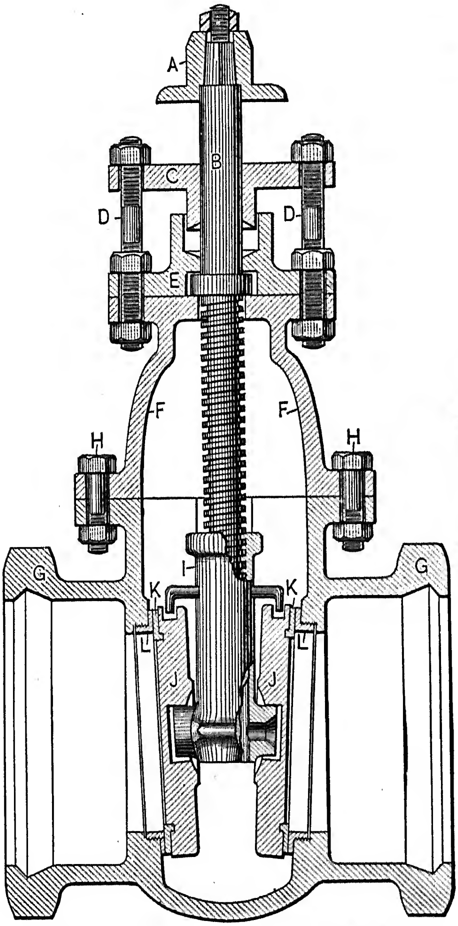


FIG. 164. Sectional View of Gate Valve.

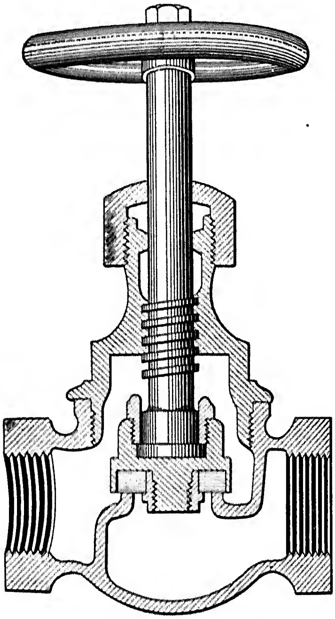


FIG. 165. Sectional View of Globe Valve.

ings, inlet and outlet, placed at right angles. It is the handiest form of valve to use at the suction end of pumps. In the smaller sizes (½ and ¾ inch) it is also much used to control the branch supplies to plumbing fixtures.

Swing check valves are illustrated in Figs. 166 and 167.

Flushing Cisterns. — All plumbing fixtures into which human waste matters are passed — water-closets, slop-hoppers and urinals — should always be thoroughly flushed by a separate **flushing cistern.** Of these there is such an endless variety that I shall not attempt

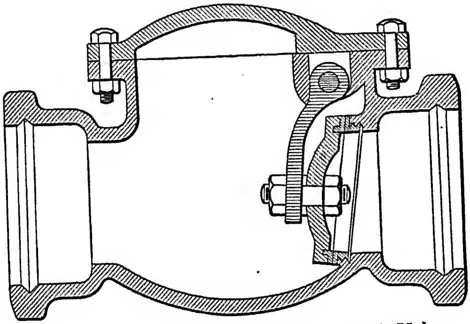


FIG. 166. Section of Horizontal Swing Check Valve.

to describe them beyond stating that some are emptied by the lifting-up of valves, while others are discharged by means of siphons. We thus have two principal classes, valve and siphon cisterns. Each may be operated in a variety of ways, either by a simple chain-

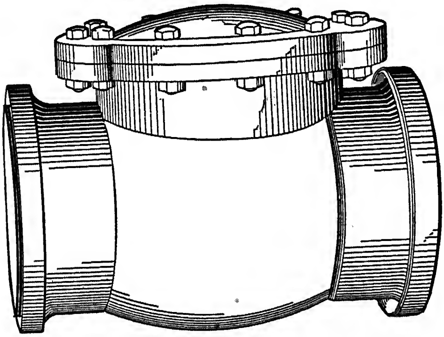


FIG. 167. View of Check Valve.

and-pull handle, or by a lift handle, lever, fulcrum, and chain, by a seat action, or by the opening and shutting of the door of the water-closet compartment.

Occasionally the chain is operated by a bell knob with wire buried in the plaster work. One kind of cistern is operated and started

by a pneumatic tube and a push-button device; in another invention a knob, upon being pressed, starts an electric current which in turn causes the siphon in the cistern to operate. As a rule each closet is sold with a special cistern, which it is best to buy with the water-closet fixture, and in fitting up the complete apparatus one should follow closely the printed directions of the manufacturers.

A new **combination automatic and pull tank** is shown in illustration, Fig. 168, and its supply arrangement more in detail in Fig. 169. Such a device is particularly useful in hospitals for the insane, where it is found that in some wards the patients will think of pulling the chain, whereas, in other wards, the automatic flush must necessarily be used. The same appliance would be serviceable in toilet rooms of schoolhouses. I have found this type of tank very useful in houses where servant's yard closets are not sufficiently protected against freezing. Normally, the pull flush is used, while in very cold weather the automatic flush is turned on, whereby the closet is kept from freezing.

Flushometer Valves.—In recent years a substitute for the common flushing cistern with flush pipe has been introduced, and is known as a **flushometer valve.** There are several makes and types of these. They require a very large supply, not less than 1½ inches and a full pressure of water. Some of the valves are adjustable for a high and a low pressure, and moreover can be set so as to operate with a smaller or larger quantity of water. On an average, they discharge about 5 gallons at each flush, though I have been shown some which flushed a closet bowl successfully with less than 3½ gallons.

The flush valves in buildings should be supplied from one separate large service tank and require an independent system of pipes, all of which tends to render their installment as expensive, or even more so, than overhead or high flushing cisterns. Some makers claim as an advantage that they flush noiselessly. My experience has been that when this is the case the flush is feeble, unsatisfactory and sometimes insufficient to clean the water-closet bowl properly. Flushometer valves, the operation of which appeared to be satisfactory, made as much noise as the high tank with long flush pipe. I therefore cannot bring myself to be in favor of them, except in

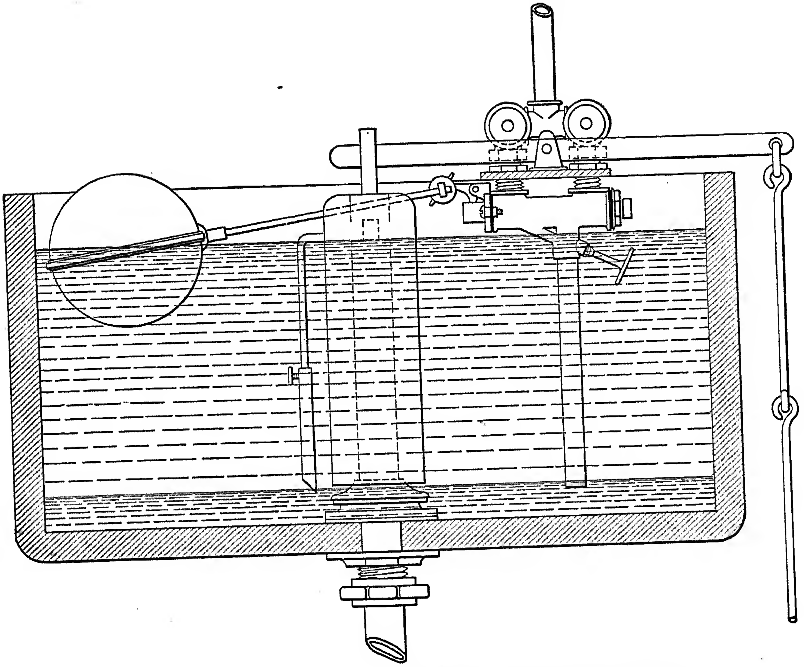


FIG. 168. Detail of Automatic and Pull Water-closet Cistern.

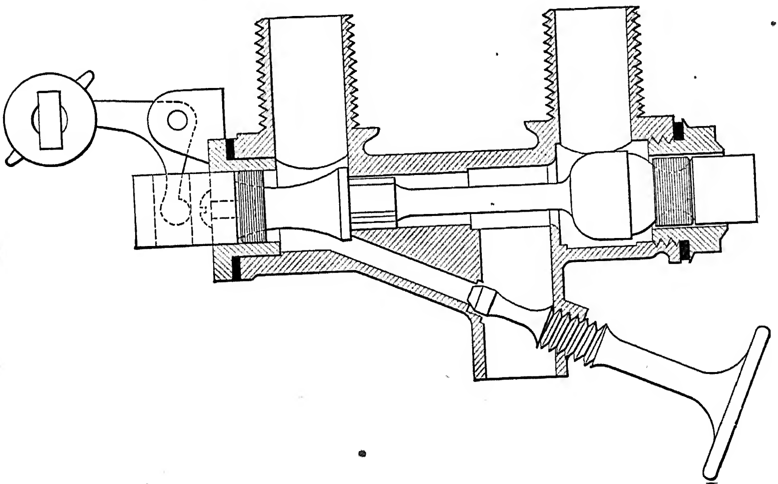


FIG. 169. Detail of Double Supply to Tank Shown in Fig. 168.

rare and special instances. Urinals and slop-sinks have also been arranged to be flushed by means of such valves.

Low-down Tanks. — Water-closets are also sold with flush tanks located just above the top of the closet bowl, and such fixtures are known in the trade as **low-down tank combinations.** They are installed where sufficient headroom for a high tank is lacking, for instance, under stairways and in attic bathrooms, with low pitched roofs. This type of flushing tank requires a large connection to the closet bowl, which must be specially manufactured. I have found them to operate very noiselessly and in general satisfactorily, so that I prefer them to the flushometer valve closets.

Sizes of Supply Pipes. — As regards the **sizes of service pipes** for domestic water supply, the almost universal custom of plumbers is to put in pipes of insufficient caliber. Instead of following the correct principle of "small waste pipes and ample supply pipes," the usual foolish practice is to use waste pipes of too large and supply pipes of too small bore, thus working a twofold harm.

Again, it is too often the case that no proper consideration is paid to the adjustment of the various sizes of distribution pipes in a building. This question has a special bearing on high buildings and large office, factory or warehouse structures. In the case of ordinary two-story and attic dwellings the matter is not of great importance; yet even with these a certain saving may be effected by proportioning the different parts of a line of service pipe to the duty it has to perform, in other words, by making a line of pipe and its branches of such sizes that, no matter how many faucets are opened on different floors simultaneously, water will flow freely through each of them.

Every householder knows the annoyance of trying to fill a wash-bowl or a bath tub when water is being drawn at some fixture on one of the floors below. This whole question belongs essentially to the science of hydraulics, and to solve the problem successfully it requires a close study of the laws governing the flow of water through pipes of various areas and under variable heads or pressures. Houses piped scientifically are not often to be found. The average mechanic or so-called "practical man" has too profound a distrust or contempt for everything savoring of theory to be

induced to look into this question, which is, in its results, decidedly a *practical* one.

The following **internal diameters for supply pipes** may, with ordinary pressures, be adopted as securing an ample supply at a single plumbing fixture. The size of the main lines depends upon the number of branches taken from them, but also upon the above-mentioned conditions, and it will not be necessary to discuss these. For a kitchen sink it is usual to run a $\frac{3}{4}$-inch service pipe, for a pantry sink a $\frac{5}{8}$-inch pipe is ample, for a washbowl a $\frac{1}{2}$-inch pipe, for a set of laundry tubs $\frac{3}{4}$- to 1-inch pipe, for bath tubs a $\frac{3}{4}$-inch, and for water-closet cisterns a $\frac{1}{2}$-inch pipe, always supposing that the house is supplied under the ordinary tank pressure. Fixtures are frequently supplied with pipes of smaller bore, but the resulting insufficiency of the water supply is one of the usual defects in ordinary plumbing. If lead pipes are used they should weigh at least as follows:

$\frac{1}{2}$-inch pipe, 2 pounds per running foot.
$\frac{5}{8}$-inch pipe, 3 pounds per running foot.
$\frac{3}{4}$-inch pipe, 4 pounds per running foot.

Insufficient strength and weight of supply pipes frequently cause them to burst and leak.

Sizes of Service and Taps. — The customary **sizes of taps** for the supply of buildings is referred to in the next chapter. The discharges of taps and service pipes may be increased by enlarging the diameter of the services immediately at the tap. Diagrams giving the delivery of water under such conditions are introduced in Chapter VI, so that it does not seem necessary to refer to the matter in this place. Diagrams for the discharge of service pipes (without consideration of the size of the tap) are given in Chapters I and VIII.

Pipe Joints. — A few words should be said in regard to the **manner of making pipe joints.** When lead service pipes are used, all joints should be wiped solder joints, in which an oval lump of solder is wiped around the joint in order to reinforce it. Ordinary cup joints are not so strong and should not be used on supply pipes, except where brass couplings of bibs are connected with lead pipes. All joints between lead pipes and brass stopcocks should

be wiped with solder. In making such joints the plumber must avoid the falling of raspings and filings into the pipes, which, when lodged under the valve seats, cause damage to washers and obstructions to the free flow.

Lead and wrought-iron pipes cannot be soldered together, hence a brass ferrule or screw nipple is used, which is soldered to the lead, and screwed tightly into the fitting or on the wrought-iron pipe. In the case of tin-lined lead pipes it is better to use special tinned brass ferrules and tees to join them, as explained heretofore.

If wrought-iron service pipes are used, joints are made by cutting screw threads on the ends of pipes and connecting pipe ends with couplings or fittings, as the case may be. Usually a paste of red and white lead mixed is used to act as a lubricant and to make up for imperfections in the threads when the pipes are screwed up tightly with pipe wrenches or pipe tongs. Sometimes linseed oil only is used, which, after setting hard, makes a tight joint.

Enameled wrought-iron pipes should be put together with liquid black enamel, and in joining tin-lined wrought-iron pipes the special tinned brass ferrules, sold with the pipe, should be used. Brass service pipes are connected by means of screw joints, a paste of red lead being put over the threads to insure tightness of joints. A good precaution where a house is piped with wrought-iron service pipes is to insert in suitable places a number of right- and left-hand sockets, or, still better, ground union couplings, to allow of removing a length of pipe for repairs, or alterations, without taking down a whole line of pipes. As soon as the piping is finished it should be tested by turning water into the pipes, and applying a heavy pressure by means of a hydraulic testing pump and gauge. Any leakage indicating imperfections in the joints or defects in the pipes should be remedied at once.

General Arrangement of Water Pipes. — The **arrangement of the supply pipes** in a house is, so far as subsequent annoyance, owing to the constant necessity of repairs, is concerned, one of the most important matters connected with its water supply. Far too little attention is, in the majority of cases, paid to it by architects and builders.

In the first place, it is important that all lead and also tin-lined and block-tin pipes be well fastened to boards or narrow strips of

wood, nailed to walls or ceilings. Vertical lead pipes should be supported by soldering hard metal tacks to the lead pipes and fastening them with screws to the board. All sagging is thus effectively prevented, provided the supports are not placed too far apart. Horizontal or graded lead pipes should be firmly supported, wherever possible, throughout their entire course, by strips of wood on which they rest, and should be kept in place by brass straps or clamps. Sometimes it is necessary to fasten horizontal lead pipes to boards nailed to the under side of ceilings. In such a case the supports must be placed very close together — say every two feet. If insufficiently fastened, lead pipes are soon dragged down by their own weight, besides being affected by changes of temperature, for when hot water passes through the pipe it causes the pipe to lengthen and hence to sag, while lead does not return to its original shape on cooling. Once out of line, pipes become air bound, or freeze in winter and leak.

Ordinary hooks should never be used in fastening lead pipes. Hot-water lines should always be so fastened as to allow for expansion and contraction, hence it is better to use brass straps in place of tacks on lead pipes. Brass or wrought-iron pipes need no continuous support, but should be put up by means of adjustable iron- or brass-pipe hangers, which make a neat and finished looking job.

The aim should always be to make the whole arrangement of supply pipes as simple, compact and direct as possible. It has been truly remarked that "the course which water pipes take in a house often proclaims the skillful mechanic." Long horizontal runs under floors should be avoided wherever possible. All lines should be arranged neatly and laid out so that they do not cross each other or dip one under the other. No line of supply pipe should have unnecessary depressions or dips, in which water stands which it is difficult to drain, nor should it be bent up in its course, thereby becoming air bound; and while this rule applies to all lines, it is particularly important in the case of hot-water pipes to avoid an interruption in the circulation.

Hot- and cold-water pipes should be kept at least one inch, and better several inches, apart, to prevent loss of heat from one to the other. Where they run in the same direction, they should be

fastened truly parallel to each other. Faucets, and in particular ground-key and self-closing bibs, should not be placed at the end of a line of supply pipe, where this can be avoided, but should be taken from the side of the pipe, and the pipe suitably continued so as to form a small air chamber.

In arranging a system of service pipes in a dwelling the cardinal rule should always be observed that **all lines of supply pipes be so graded that they may be readily and completely emptied** at some stop-and-waste cock or draw-off faucet, when the water is shut off from the house. This is very important in the case of very severe cold weather to prevent the freezing of pipes, as we shall see further on, and it is an absolutely necessary condition in the case of all houses left empty during the winter months, such as summer and seaside residences, etc. In this connection it may be well to state that no check valves should, as a rule, be used in lines of supply pipes. Where used, their number and location should be remembered and noted by the house owners, for such check valves interfere with the complete emptying of the pipe lines.

This leads me to mention the importance to the house owners and tenants of having a plan of the water supply of the house for reference in case of accidents, repairs or alterations, which plan should show all lines of pipes, all stop valves, faucets, location of fixtures, check valves, etc. I would also point out the necessity of having stop-and-waste cocks arranged in accessible places, to isolate and shut off each branch line separately, thereby avoiding the annoyance and inconvenience of having the water shut off from the whole house for hours at a time, or even longer, when perhaps a slight repair is required at a single fixture. This also applies to such lines which supply portions of a house which are particularly exposed, and which it may be desirable to shut off without interfering with other fixtures in the house. In the best work stopcocks, for both hot and cold water, are arranged at each fixture and at each flushing cistern to enable one to shut off any one of them separately.

Another principle which should be strictly observed is to **arrange all service pipes so as to be readily accessible.** Therefore water pipes should always be run in sight above the basement or cellar floor and be kept out of partitions, board and parquet floors, and

not buried in plaster work where it is difficult to get at them in case of needed repairs.

Many architects and builders prefer to hide or bury the pipes, but I consider this a great mistake, which many a house owner has found out when too late, by costly damages to his property.

It is better to insist upon having all pipes in plain sight; not only is the advantage secured thereby of being able to trace the course of every pipe in case of inspection without the necessity of moving boards or cutting plastering, but the very fact that all piping remains in open view compels the mechanics, plasterers, painters, carpenters and plumbers to finish their work in a superior manner. Without doubt, leakages are less liable to remain unnoticed if all pipes are arranged in sight.

In rare cases it may be necessary in passing through principal rooms on the parlor floor to cover the pipes up by a finished board or casing which should be hinged and be formed like a narrow paneled door which can be readily opened. Sometimes pipes must be run for a short distance between floor and ceiling. In this case they should not be fastened to the beams, but be laid on boards, put on strips nailed to the side of the joists, and properly graded. The floor boards should be fastened down with screws or else trap doors should be arranged so that one may be able to get at the pipes without difficulty. Usually pipes may be left fully exposed, and there is nothing unsightly in a well-finished job of piping. If desired, wrought-iron service pipes may be bronzed or gilded for appearance's sake. Brass pipes may be shellacked, which protects them against corrosion. In the most expensive work such pipes are nickel-plated. Lead pipes may be varnished, but in no case should lead or brass pipes be painted.

In case of large buildings and especially where many different pipe lines are carried up in special pipe shafts, it is well to **label each pipe and stopcock** to insure its correct use at times when needed. It is impossible to foresee when the pipes in a building may want looking after, and it is the part of wisdom to make provision for such occurrence by keeping the pipes and stopcocks where one can lay hands on them in case of an accident. It always pays to do so, and where one meets with strong objections against an open arrangement of pipes, an explanation that it is

more economical to do so, in other words, an appeal in the interest of the owner's pocketbook, generally secures his consent.

Wherever supply pipes necessarily must run between floors and over expensively decorated ceilings, it is better to provide a zinc safe properly graded, enclosing the service pipe, and arranged with a drip pipe to carry off leakage, or water from condensation in the case of iron pipes. As a rule, however, it is better to arrange the entire pipe distribution at the basement, or sometimes at the cellar, ceiling.

Prevention of Noise and Water Hammer. — One of the requirements of a good plumbing system is that it should be perfectly **noiseless** in all its parts. It is, however, a rather difficult matter to accomplish this.

Noises in plumbing pipes and fixtures are of different kinds and due to a variety of causes. Sometimes the water pipes transmit an objectionable noise, heard more or less throughout the whole house. At other times it is the kitchen boiler which emits rumbling sounds. Many water-closets have a very noisy flush, or the flushing cisterns refill, after emptying, with a loud noise, or the ball cock emits a whistling sound. Again, the noise of water flowing through a soil or waste pipe may be heard in a reception room or library, or where water is pumped the pump riser may transmit the noise due to the operation of the pump, or one may hear all over a house the noise due to the filling of a bath tub, where the bath bibs are placed near the top of the tub. Finally, the shock due to water hammer in pipes may be transmitted and annoy the inhabitants of a dwelling or apartment.

For some of the noises mentioned the remedy is not difficult to find and easily applied, but in other cases the abolishment of the noises may puzzle even the best experts.

Noises in the kitchen boiler have been referred to under the description of the hot-water apparatus. The noisy refilling of cisterns may generally be stopped by providing the water-inlet pipe with a so-called "hush pipe." It is difficult to stop entirely the noise, caused by the flushing of water-closets and due to the falling water, which in passing through the flush pipe must drive out the air before it. The "Sanitas" closet is probably the most noiseless closet on the market, this being due to the special arrangement

adopted, whereby the flush pipe is always kept full of water, so that there is no air to drive out (see Fig. 83). In other closets, like the "Silentis" closet of Mott's, the flush pipe is provided at its lower end with a regulating screw, the adjustment of which reduces the noise, but also the force of the flush.

It is generally practicable to deaden the noise, due to water flowing in waste and soil pipes, by covering the pipes with a good quality of non-conducting covering, where they pass through partitions or in wall chases having only a thin board covering.

The **pump riser** may be **made noiseless** by using air chambers at the pump, by setting the pump on a felt mattress, by adopting the device of extra-strong flexible rubber hose instead of stiff iron-pipe connections at the discharge pipe, and finally by wrapping the pump riser with a suitable material.

The noise due to the water falling into the bath tub may be avoided by supplying the tub near its bottom by means of a bell or fan supply fitting.

When the water pressure is very heavy, but also in other instances, the faucets sometimes emit a roaring sound, especially when opened only part of the way. Very often this is caused by loose washers in the bib, particularly so in the case of the Fuller faucets; in some instances, however, the noise is due to a part in a shut-off on the pipe line having become loose. At other times a jarring and vibration of the supply pipe occurs, combined with more or less noise. In such cases it should be remembered that the material of the pipes has nothing whatever to do with it. A little careful watching as to the exact position where the noise originates will generally help to indicate the remedy to be applied.

Noise in the water pipes due to water hammer can usually be effectually stopped by the use of pipe air chambers placed directly at the faucets, or a spiral tube device, known as an anti-water-hammer attachment, may be used and fitted up directly where the water service enters the dwelling.

Water Hammer in Pipes. — When water flows through a pipe under pressure it acquires, much the same as solid bodies in motion, a certain momentum. When the flow is suddenly checked or shut off, this momentum causes a shock, not only at the valve gate but also in the water pipes, which is technically termed **water hammer.**

Experiments have confirmed the view, held by practical engineers, that air chambers of suitable size and capacity act as cushions and thus tend to greatly reduce the force of the water hammer. Where the water pressure is very great, it is advisable to use stopcocks and gate valves which close very slowly. Under such conditions, compression faucets are much to be preferred to ground-key, Fuller or self-closing bibs; fire hydrants should always be shut off very slowly. The more time is taken to close a faucet, valve or hydrant, the smaller will be the impact. The maximum pressure due to water hammer is sometimes ten to twelve times as high as the initial pressure, and, even where good air chambers are used, the pressure sometimes reaches four to five times the static pressure.

Air chambers are vessels, or vertical pipe enlargements of suitable size, attached to supply pipes, either at their extreme upper ends, or very near the faucets, and containing an air cushion which is intended to receive a part of the blow, due to water hammer. Water gradually absorbs the air of these air chambers and hence proper provision should be made for recharging them. Horizontal pipe extensions intended as air chambers do not fulfill the object for which they are put in.

Important **experiments on water hammer** were carried out some years ago at the Imperial University of Moscow, at the suggestion of the late Mr. Nicholas P. Simin, when chief engineer of the Moscow water works, and under the direction of Prof. N. Joukowsky.

These experiments were made on an elaborate scale, and the results were summarized by the author as follows: —

1. Hydraulic shock is propagated along a water pipe with a constant velocity. The velocity does not depend on the force of the shock, but upon the material of the pipe and upon the ratio of the thickness of its walls to its diameter. The velocity of propagation of the shock wave is somewhat smaller for large pipes than for pipes of medium size.

2. Hydraulic shock is propagated in a pipe with a uniform force. With the usual cast-iron pipe of medium diameter, a pressure is created by the shock equal to four atmospheres (59 lbs.) for each foot per second of velocity lost; in large pipes it is smaller, viz., three (44 lbs.) atmospheres.

3. The shock is determined only by the lost velocity.

4. A dangerous increase of pressure due to shock arises in the passage of the wave from large to pipes of small diameter. In this way the pressure of the shock may be doubled when it reaches the closed end of the pipe. The remedy is to use long increasing or reducing fittings in place of the ordinary "bushings."

6. The simplest means to protect water pipes from hydraulic shock appears to be to use devices to secure a slow closing of valves and faucets.

7. The duration of the closing must be proportional to the length of the pipe.

Regarding air chambers, the report states that if they are of proper dimensions and if they are placed near the valves and the cocks, they destroy almost entirely hydraulic shock and do not permit the shock waves to pass through them when they are placed upon the line of the pipe. But the preservation of air in the chambers is very difficult.

Safety valves placed upon the line of pipe allow to pass by them only a shock corresponding to the elasticity of the spring. (See also Chapter VII.)

Prevention of Freezing of the Supply Pipes. — Many of the repairs required at service pipes are caused by the **freezing of the pipes.** This is a matter which interests householders more than other details of plumbing work. It is also a matter in which ignorant plumbers or unscrupulous builders frequently sin, as householders or tenants generally find out during the first winter spent in a newly erected residence. In cold climates and exposed situations much damage to property is caused by the effect of frost on plumbing work. It will therefore be instructive and useful to consider what measures of prevention ought to be taken to avoid the freezing of water pipes and of the plumbing apparatus generally.

Much can be done by a judicious planning and a regard to a proper location of plumbing apparatus, tanks, fixtures, and supply pipes, when the work is first constructed. One should avoid all exposed corners of a building, and should put up plumbing fixtures only in rooms and closets to which heat can be supplied in winter time, either directly or else by keeping open, on extremely cold days, the doors to an adjoining warm apartment.

Water pipes should never be run on the outside of walls or in

places where they could be affected by frost. If necessarily placed where they are exposed, they should not come in direct contact with external walls, which are easily penetrated by the cold, but should be fitted up on boards nailed to narrow strips, fastened to another board attached to the walls. The air space between protects the service pipes to some extent. It is well to plaster the wall in such a case and to fasten the boards to the plastering. In addition to this it may be well to wrap the pipes up with non-absorbent, non-combustible, non-conducting material, such as felt, asbestos, or mineral wool.

Cold or exposed places in basements or cellars, and spare rooms in upper floors, should not contain any service pipes. Such pipes should also never run in front of cellar windows, especially at the north and west side of the house. In country or suburban residences it is well to fasten the cellar doors before cold weather sets in, and to see to it that all windows are closed and broken windows repaired in order to retain the warmth of such places.

The open arrangement of fixtures, which I have recommended on sanitary grounds, is also of some usefulness in preventing traps or supply pipes from freezing. For the same reason it is better to keep pipes out from between joists, and to run them exposed along ceilings of pantries, kitchen or the laundry where the temperature of the air is generally higher. All pipes exposed to cold-air currents in shafts are very liable to freeze unless suitably packed.

Where service pipes are run in chases or recesses in walls, or in vertical hollow flues between the studs of partitions, it is very necessary that all upward currents of air from the cellar be prevented, and all draughts cut off, by closing up the openings between floor and ceilings on all floors, with plaster-of-Paris, cement, or otherwise. This is a matter frequently neglected where plumbing is boxed up and hidden from view, and the consequence is the continuous freezing of pipes at every cold spell, even where they are, to all appearances, properly located.

But even where plumbing work is properly located and the pipes well arranged, it may become necessary to observe certain **other precautions to prevent the freezing of pipes.** A popular remedy, but one which cannot be approved of as it causes an enormous waste of water, is to keep some faucet open during cold nights,

allowing the water to run into the fixture. This plan, while avoiding successfully one evil — the freezing of the supply pipe — very often causes in the end the same serious annoyance, and often damage from overflow owing to the freezing of the waste or soil pipe. It has come to be usually regarded as unobjectionable to locate soil or waste pipes in exposed or outer walls, the supposition being that, as they never contain any standing water, there is no danger of freezing. This is true, but it does frequently happen, where such pipes are put in exposed places, that a very slow, trickling flow of water from a faucet passing through the pipe becomes chilled, freezes and causes an obstruction to the soil pipe. Hence it is a wise precaution, before winter sets in, to examine all faucets and water fittings, and to repair those which are defective and dripping.

It is also important to ascertain whether all stopcocks and shut-offs are in proper working order and readily accessible. If this is the case, the best preventive measure against the freezing of pipes in very cold weather is the shutting off of the water supply, and the complete emptying of the pipes. It will now become apparent why the proper and careful grading of all service pipes so that they can be completely emptied is recommended. It will also be understood why sags or depressions in a line of water pipe of a house unoccupied during the winter season may cause the bursting of a pipe, and damage the ceiling when the water is again turned on in the spring.

Where the system of water supply of a dwelling is arranged as heretofore described, the **emptying of the pipes** is accomplished as follows: First, shut off the main street supply at the cellar wall, open the draw-off faucet (in case there is a stop-and-waste cock the water runs out at the small waste hole) and turn open those faucets which are located on the rising main line. This last precaution is necessary in order to completely drain the pipes. Householders often simply shut off the main supply, forgetting to empty the pipes, which consequently remain full of water, and freeze. The next thing to do is to empty all pipes supplied from the tank. Where the latter is located in a warm corner, the water may be retained in the tank; and the rising main is emptied by closing the stopcock at the tank or the cistern valve in the tank and opening

the lowest faucets when the pressure of air supplied through the air tube, which ought always to be provided, causes the water to flow out at the taps. If the tank must also be emptied, this should be done by means of the large blow-off pipe, and not through any of the smaller service pipes, which may become partly or entirely choked with sediment from the tank.

Care of Tanks.— Tanks and cisterns should always be located where they cannot freeze, and where they will be easily accessible for inspection and cleaning. Their overflow pipes, if carried into the open outside air, should be protected against cold draughts by a hinged flap valve placed at the mouth of the pipe. The **operation of cleaning** should be performed at least every three months, if drinking-water is drawn from the tank. It is better, however, to draw drinking-water at the pantry sink, which should be supplied from direct pressure. It is a good plan to fit a well-made cover over the top of a drinking-water cistern, but in this case aëration should be provided by carrying two pipes from top of tank to above the roof. The weight of a large tank should be properly distributed. Where the tank is located over a good room, or an expensively decorated ceiling, a safe of sheet lead or zinc, with well-turned-up edges, should be placed under the tank, and a large drip pipe should run from it to the nearest fixture, to discharge any accidental leakage.

Service Pipes. — The term **service pipe** should be used only when speaking of the supply line which carries water from the street main into the building. The service pipe ends just inside of the cellar wall. The pipes supplying the plumbing fixtures in a building should be called **house-supply pipes.**

Regarding the best arrangement of the service pipes outside of the house, the rule should be followed to lay all such service pipes sufficiently deep in the ground to be below frost level,— at least four and one-half feet in the New England States, and not less than three feet in localities which do not experience very severe winter weather.

Street mains are sometimes placed at a lesser depth, because of the fact that the water in them is constantly in motion. Where the main, as is sometimes the case, is only three feet deep, the service pipe should be protected at the junction and turned down until

it reaches the above-mentioned depth. In entering the foundation walls of a building, it is best to insert a cast- or wrought-iron pipe of larger bore, through which the service pipe may pass, the joint between the wall and the pipe sleeve being made water-tight.

It should be mentioned that in some made or filled-in ground containing cinders, chemical refuse, lime, or furnace ashes, pipes of wrought iron are subject to a very rapid corrosion. To avoid this, the pipes should be painted on the outside, and placed in clay puddle or be covered all around with cement or sand.

Connections with the street main are usually made by inserting a **corporation stopcock** by means of a **tapping machine.** The corporation stopcock is a brass fitting, which is sometimes driven and sometimes screwed into the main pipe. It should have a full waterway. In the smaller sizes a main coupling connects the lead or galvanized-iron service to the tap, short pieces of bent pipe being inserted to attain a certain degree of flexibility to prevent breaks from settlements in the trench. For larger sizes a pipe loop, made of short pieces of pipe and elbows, is used.

Until quite recently the corporation tap used in New York City was of a type which practical engineers condemned as being very defective. It was merely a brass tapered hollow plug, driven into a hole drilled into the shell of the street water pipe, and it very often and very readily became loose and leaky in consequence of a strain on the service pipe. A large part of the enormous water waste occurring in New York City is doubtless due to this faulty method of connection, which is not used anywhere else to my knowledge.

It is always advisable to arrange for an outside or **sidewalk shut-off** cock or valve on the service pipe, so that the water may be shut off from a building without entering the same. This also obviates the necessity of the city Water Department digging down to reach the corporation cock to shut off the water in case of need.

Two matters, which are of much importance in connection with the water supply of habitations, and which require special mechanical equipment and installations, have not been gone into. One is the **household filtration of water,** by means of mechanical or **pressure filters** for the general supply, and by the use of **germ-proof filters** for

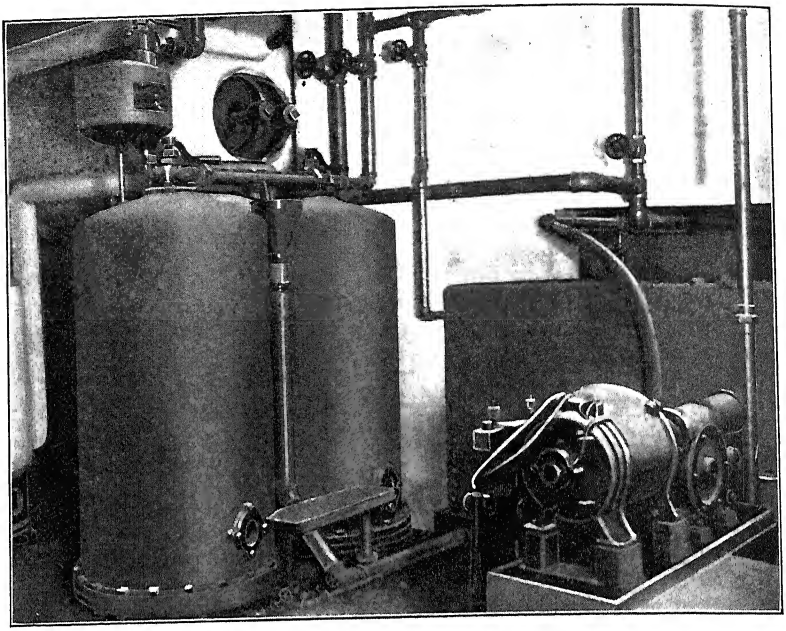
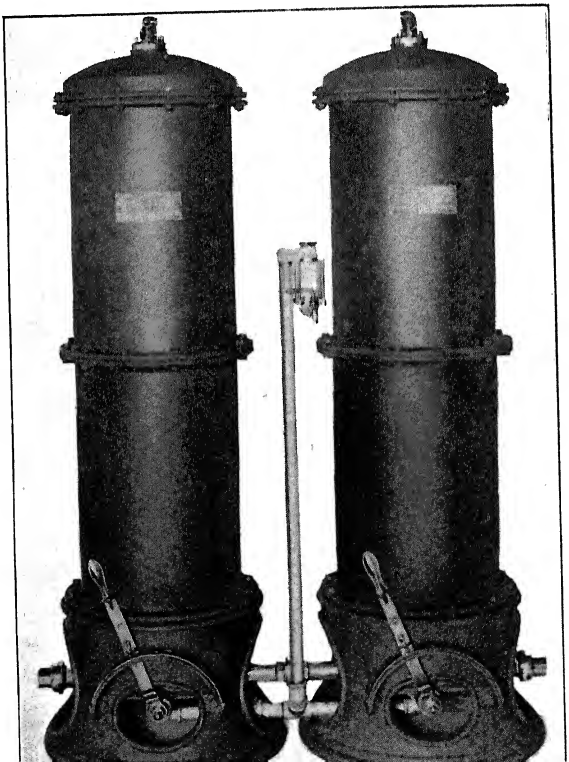


FIG. 170. View of Mechanical or Pressure Filter.



the limited supply of drinking-water. The other is the selection of **power motors** for the lifting, or **pumping,** of the water into the house tanks, and which comprise caloric or hot-air engines, gas pumping engines, hand pumps, steam and electric house pumps. Some of the more frequently used house filters are, however, illustrated in Figs. 170 and 171, and an electric screw house pump in Fig. 170. For other house pumps see Figs. 186, 187, 188 and 189 in Chapter VI.

The pumping of water for country houses by means of hydraulic rams or engines, by windmill pumps, by air lift and other devices, and isolated water-supply plants in general are discussed in the author's book, "The Sanitation, Water Supply and Sewage Disposal of Country Houses." 1909.

The next chapter will deal more in particular with the water supply of large city buildings.

CHAPTER VI.

THE WATER SUPPLY OF LARGE MODERN CITY BUILDINGS.

Mechanical Equipment of Large Buildings. — The **mechanical equipment of modern large city buildings** has been the topic of many discussions in recent years, but while much attention has been given to the steam-boiler plant, the heating and ventilation system, the elevator equipment, the electric-light and power installation, and the refrigerating machinery, the **water supply** and incidental fire protection of such buildings have usually been passed over with only a few words.

The Water-supply Plant. — Of all the complicated engineering equipments of large buildings the **water-supply plant** is, in my judgment, second to none in importance. Not only is the supply of wholesome water for drinking a very essential sanitary requirement, but the running of the boilers, of the hydraulic elevators, of the refrigerating and ice-making machinery, and of other apparatus depends upon a proper and abundant water supply.

A modern large building, be the same an office or other commercial building, a department store, a hotel or a hospital, requires the planning and construction of an elaborate water-supply equipment which is often more intricate and therefore more difficult to design than that for a town of good size. Large buildings, like those mentioned, may be aptly considered as small communities, whose many needs and requirements for comfort and convenience must be carefully studied and provided for by the engineer, if the building is to be considered suitable for the purpose for which it is erected, and if it is not to prove commercially a failure, where it contains offices let to tenants. A large amount of study, care, skill and practical experience is required to lay out and provide an efficient water-supply plant for such buildings.

Water is **required** in them **for many** and varied **purposes,** such as for drinking at sinks and drinking fountains; for the daily ablution in lavatories, bath tubs, shower and spray baths; for washing pur-

poses, in the laundry; for the cooking operations; for the supply of the heating boilers; for the running of the hydraulic elevators; for the ammonia condensers of the refrigerating plant and also for the ice-making apparatus; for the flushing of water-closets, urinals and slop-sinks; for the washing of windows, cleaning of floors and scrubbing generally; for the sprinkling of sidewalks, courts and yards; for ornamental fountains; for watering flower beds, gardens and lawns, and last, but not least, for fire-extinguishing purposes.

For some of the purposes named **hot** as well as **cold water** are required, and for drinking purposes the water is frequently **cooled artificially.** Special apparatus for **distilled,** for **sterilized** and **aërated** or **carbonated water** is required in the modern hospital. Sometimes water of different degrees of purity is provided for; thus, deep well water, even if unsuitable for drinking, may be utilized for the ammonia condensers and for the washing of floors and windows; a **salt-water supply** is in some cases provided for bathing, for flushing out the fixtures of toilet rooms and for sprinkling and fire service.

Requirements for a Water Supply. — Whatever the character of the water supply may be, three matters of paramount importance interest us, namely, the **quality,** the **quantity,** and the **pressure.**

The water must be pure and wholesome, it must be available in ample volume and it must flow on all floors of the building under a good, though not excessive, pressure. **In a well-designed water-supply plant all three conditions must be fulfilled.** Where only one or two are provided for, while the others are lacking, the system is necessarily more or less imperfect.

In arranging for the supply of city buildings, we are compelled to take the water as it comes from the street mains, unless we choose to take the rather uncertain course of providing an artesian-well supply, which more often than not proves a failure. If we take the city water, we cannot control any of the three requirements named above.

If the quality of the water is not above suspicion, it should not be used for drinking purposes without previous filtration or distillation; if the water is full of suspended impurities or muddy and turbid, it will foul the house pipes and tanks and leave deposits in the steam

boilers, and therefore means must be provided to clarify it by straining it in large filters.

If the pressure of water is insufficient, it will fail to supply more than the lowest floors directly, and the bulk of the water used in the building must be pumped. If the street mains are too small, the quantity available per minute will be insufficient, and provision must be made in the building for the storing up of a large volume in storage tanks (both in surge tanks and in house or pressure tanks), in order to maintain a sufficient supply during the hours of maximum consumption, when the supply available from the city connection is usually the smallest.

Water supply Equipment. — The **water-supply plant for large buildings comprises:**

(*a*) corporation taps or large branch connections with the street mains;

(*b*) service pipes to bring the public supply into the buildings;

(*c*) fish traps to prevent any obstructions such as eels or fish in the street mains from getting into the meters and house pipes;

(*d*) gate and check valves to control and shut off the entire supply;

(*e*) water meters to measure the consumption for the purposes of establishing the water charges or rates to be paid by the owner;

(*f*) water-filtering apparatus to clarify and render suitable for general use the entire water supplied by the street mains;

(*g*) suction or surge tanks into which water flows from the street connections, to be stored and made available for the pumps;

(*h*) water-pumping apparatus, comprising house and fire pumps to make the water available for the upper stories and for fire service;

(*i*) storage tanks to cause a flow of water under suitable pressure, the storage being effected by either roof and intermediate tanks or by pressure tanks;

(*j*) water-distribution lines, forming either a header or a circuit system with the necessary controlling valves;

(*k*) supply risers for cold and hot water and branches to the plumbing fixtures;

(*l*) to which are often added circulation lines for the hot water;

(*m*) besides numerous other accessories, such as hot-water heaters, with sight or recording thermometers and thermostats,

gauge boards with steam-, air- and water-pressure gauges, air compressors and air-storage tanks;

(*n*) and finally the necessary fire-protection and fire-extinguishing apparatus, comprising fire pump, inside lines of standpipes, with fire valves, hose and nozzles, reels or racks to support the hose, and outside or street connections for the fire department.

Before taking up more in detail some important parts of such a water-supply plant, a few general considerations regarding quantity, quality and pressure may be helpful to a correct understanding of the subject.

General Considerations.

Amount of Water Required. — In planning the water supply for a proposed large building the first thing to determine is the **maximum daily amount of water** required. This will necessarily depend upon the character of the building, its size, number of stories, and the number of tenants, both temporary or transient and permanent. Where the building is intended for occupancy day and night, as, for instance, in the case of a hotel or a hospital or other institution, a larger volume of supply is required than where the building is occupied for only a certain number of hours per day, as in an office or commercial building. It is furthermore a matter of observation and record that the consumption of water in a building increases with the number of plumbing fixtures provided. The greater the number of faucets or taps, the more water will be consumed, or rather wasted, through faucets carelessly left running.

A fair and generous **average allowance for domestic consumption** per capita per diem would be sixty United States gallons of water. If the total number of persons occupying the building can be ascertained beforehand with any degree of accuracy, the supply required by them can be estimated, but to this quantity should then be added the supply for the boilers, which is very large where steam is generated not merely for heating but also for power purposes, the supply required for high-pressure boilers being at least four gallons (30 lbs.) per horse-power hour. A further increased allowance must be made if the building is to contain a refrigerating plant, for if this is kept constantly running, as is usual where refrigerators and ice boxes are kept cool by brine circulation, the amount of water consumed

is sometimes very large, being from $1\frac{1}{2}$ to 2 gallons of water per minute per ton of refrigeration, according to the temperature of the water.

In large buildings it is also of much importance to keep an abundant **supply of water** under suitable pressure available **for fire-extinguishing purposes,** besides a further supply in large surge or suction tanks to be drawn upon by the pumps.

Consumption of Water. — It is a matter of record that the more plumbing there is in a building, the higher will be the per capita consumption and likewise the proportion of preventable waste. Excessive waste of water does not occur in tenements or homes of the working class, but rather in houses of well-to-do people. Among other buildings where water is used most lavishly are the hospitals for insane patients, the consumption running sometimes as high as 150 and even 200 gallons per person daily.

According to recent sewer gaugings, the consumption at the Kings Park, L.I., State Hospital, including the laundry water, was 132 gallons per person per day, and at the State Insane Hospital of West Virginia it was 91 gallons. These figures are obviously below the actual consumption for the reason that water used for sprinkling lawns, washing carriages and stables and watering horses and cattle does not reach the sewers.

In a recently opened large general hospital in New York City the writer found, by actual meter measurements, the per capita daily consumption to be at the rate of 305 gallons, a very excessive consumption, due partly to unusual carelessness in keeping faucets running, and partly to the running of an ice-making and refrigerating plant.

In one of the lately completed large New York hotels the average daily amount of water used for all purposes, including refrigerating plant, elevator machinery, heating and power machinery, as ascertained by actual meter measurements extending over a whole month, was 18,665 cubic feet, or 140,000 U. S. gallons. The average total population during the same month was 425, including employees, making a per capita consumption of $\frac{140,000}{425} = 329$ U. S. gallons.

Deducting from the above total daily supply the very large amount used by the refrigerating plant (9370 cubic feet), and also from

1000 to 2000 cubic feet for the boiler feed water, this leaves from 7295 to 8295 cubic feet or from 54,712 to 62,212 gallons for the direct use of guests and employees, which is equivalent to from 128 to 146 gallons per capita per diem.

Waste of Water. — The annual reports of waterworks superintendents of cities are full of complaints about the **waste of water,** which goes on not only in winter time to prevent plumbing from freezing, but at all other seasons. It is this constant waste, due either to willful negligence or to defective and leaky plumbing, which causes the exorbitant consumption of water of many American cities. In one recent report on waste of water, it is stated that "where no charge is made for water used in public buildings it often happens that little or no attention is given by the officials in charge to prevent the extravagant use or waste of water. For this reason the quantity used is sometimes *very large.*" Public and private institutions, which receive the water free of charge, are apt to overlook the fact that the water which they so recklessly waste represents to them a considerable money expenditure in their consumption of coal, first, for the pumping of the largest part of the water to tanks, and second, for the heating of from one-third to one-half of the amount.

Water used with the ammonia condensers of a refrigerating plant should never be allowed to run to waste into the sewer, yet this waste occurs in some buildings. Being clean water it can generally be utilized either in the feed-water heaters for the steam boilers, or it can be pumped into the hot-water tanks. It should not, however, as has been suggested, be used for the flushing of plumbing fixtures, for it is warm water at from 80 to 90 degrees Fahrenheit, and experience has shown that the use of it for flushing water-closets, urinals, and slop-sinks is objectionable. Either cold or very hot water should be used for this purpose.

Regarding waste of water by faucets carelessly left running, few water takers stop to think that "sufficient water will flow in 24 hours through an orifice no greater than a lead pencil, under an average pressure, to furnish an ample domestic supply for 360 persons, and that more water will flow through an orifice the size of an ordinary pin than would be used by a fairly economical family of 5 persons." (See also Table No. XI.)

In the face of such indisputable facts regarding water waste, would a conscientious engineer be justified in making allowance for an expected extravagant *waste* of water in the figures which he uses as a basis for the calculation of the principal dimensions of a proposed plant for a building?

Waste of water is both wanton and costly; it must be reduced or kept down, and the best way to accomplish this is to charge for the water by meter rates. No engineer should use figures indicating a very wasteful use of water in designing or laying out a water plant.

"The habit of wasting city water by people whose supplies are not metered is too deeply fixed to be easily uprooted. A few years ago a faucet in one of the public halls of Brooklyn was left open through a winter water famine, and it is a matter of record that the consumption flies up during every cold snap because people insist on leaving their taps open at night to prevent their pipes from freezing. The normal consumption of water per capita tends to increase steadily and should increase. The increase of bath tubs and the increased use of them are factors in the maintenance of the public health. But if, in addition to this desirably lavish use of public water, we are to face a widespread and growing waste from people who let the city water run directly down the sewers, nothing smaller than Lake Superior will do for the ultimate supply of New York. To prevent such wholesale waste we may have to come to a general adoption of water meters. They would tend to reduce consumption in some cases where it should not be reduced."

By the foregoing article, quoted from the *Brooklyn Daily Eagle*, the *Water and Gas Review* calls attention, among other things, to "a feature of water waste that is attracting the attention of public officials in all the large cities of the country, viz.: the waste of water in public buildings, schools, institutions, etc., which, in every locality where it prevails, is, beyond question, a heavy contributor to the general excessive consumption. Municipal economy in the use of a public water supply is very much like municipal economy in many other particulars. With the rapid growth of cities the difficulty of obtaining and maintaining an adequate supply of good water becomes a very serious one. Many cities have to go a long distance for their supplies, spending vast sums of money in the building and maintenance of conduits. Careless and unrestricted use of water causes these conduits to reach the limit of their capacity long before they should, and necessitates the building of new lines and very often the procurement, at heavy expense, of new sources of supply. It is safe to say that nearly all cities have to meet an enormous financial outlay for pumping considerably more water than is required for legitimate use."

"The waterworks officials of a city of Western New York discovered a few years ago that the consumption was fast reaching that limit, making it necessary for them to take immediate steps to reduce the consumption by stopping

all waste possible, thus prolonging the usefulness of the conduit. This led to a study of methods by which this reduction could be accomplished. The matter of public waste was taken up and the public schools of the city were selected to inaugurate the movement. There were thirty-four of these buildings, and after a test of about six months with a meter on each, a wide variance in daily consumption was shown, ranging from about 2 to about 500 gallons per pupil, showing plainly that there must have been very great waste. In one period of three months it was shown that the average daily consumption was about 20 gallons, or two-thirds of a barrel of water for each pupil. The average number of gallons used daily in all of the schools for the three months was about 450,000 gallons, or 3.6 per cent of the city's entire consumption, and represented a value, figured at the rates charged there, of about $1000 per month. No compensation was received by the water department for water used for municipal purposes.

"Little or no effort had, apparently, been made, prior to the introduction of meters, to prevent waste of water through defective fixtures, and it was further shown that such waste not only occurred during the time the schools were in session, but was also allowed to continue during vacation periods. After the placing of the meters the water was turned off from the buildings during all vacations. This fact made it evident that the use of water in the schools before they were metered was even greater than the record showed. There is no doubt that most of the waste in schools is due to lack of proper care of plumbing and to carelessness of children in leaving water running from the faucets. To remedy these conditions a thorough inspection of each school should be made with regard to the condition of the fixtures and to ascertain what circumstances exist that might tend to increase or decrease the legitimate use of water, and from this basis a reasonable per capita consumption of each school be arrived at. Whenever this consumption is exceeded to any large extent, the school officials should be held responsible. Through the hearty coöperation of both water and school officials in this matter there could be effected in every city a very great saving of water.

"The same conditions that exist in the school buildings are found in other public buildings, and the same coöperation between those who are responsible for their care and maintenance and the water department would soon remedy the water-waste evil. Even public officials and their subordinates should be educated to realize the fact that the process of furnishing water for municipal purposes is one of pouring water in great volume into one end of a conduit from which it dribbles at a thousand different points and in almost as many ways. The problem is to furnish an ample supply for legitimate uses and to stop the waste at every point possible."

The water registrar of New York City in his report for 1906 traced the enormous waste of water annually occurring in the city to

(1) Leaky faucets and fixtures;

(2) Improper arrangement of pipes of the hot-water system;

(3) The installation of hot water supply systems without proper circulation;

(4) The use of water in testing the rough work in new buildings; and

(5) The continuous flow of water at many watering-troughs for horses and at drinking-fountains.

His report also states that in 90 per cent of the buildings inspected the flushing tanks and valves were of inferior quality, and a very cheap grade of brass castings was used.

He suggests either to compel owners to put in a better quality of water fittings, or to meter the entire premises. He also calls attention to the fact that frequently hot- and cold-water pipes are run side by side throughout the premises, so that a person wanting to draw cold water has to waste several gallons before the water runs sufficiently cold. He points out a defective arrangement which is quite common, and to which I have referred elsewhere in this book, namely, that systems of hot-water piping in buildings are numerous where the circulation pipe is entirely lacking, so that when one wishes to draw hot water one has to waste a large amount before the water runs quite hot. To remedy these defects he advises the installation of circulation pipes, and the insulation of all hot-water pipes with proper non-conducting covering, so that the hot-water pipe will not heat up the adjoining cold-water pipe. All of which is, of course, nothing new, but it is praiseworthy to find the subject so ably discussed in an official report.

Estimates of Amount of Water to be provided. — In a recent engineering discussion, the following rough estimates of daily **allowance for water in office buildings** was given:

$\frac{2}{10}$ gallon per square foot of office space for ablutions (sinks, lavatories).

$\frac{4}{10}$ gallon per square foot of office space for flushing water-closets and urinals.

$\frac{2}{10}$ gallon per square foot of office space for the refrigerating plant.

It would seem to me to be better to base calculations on the number of plumbing fixtures, or upon the number of occupants, or both, rather than to average them by the floor space.

Water Taps and Services. — The data and facts mentioned should guide an engineer in the determination of the **sizes and number of water taps,** or of the branch connections for the mains. It is also necessary to take into consideration the size of the street main, and whether the main is a low- or a high-pressure main. Lastly, the

length of the service pipe or house connection plays an important part in the volume of supply, for the longer the service or branch, the greater will be the friction of the water flowing through the pipe, and the less volume of water will be discharged at the end of a pipe of given size, under the same pressure. For instance, a two-inch lead or iron service pipe, 35 feet long, will discharge under 30 pounds pressure 250 gallons of water per minute, but if the length of the service pipe is increased to 100 feet, the other conditions remaining the same, it will supply only 160 gallons.*

The ordinary size of tap permitted by Water Departments for a private dwelling is one-half or five-eighths inch in diameter; for larger mansions three-quarters and one-inch taps are conceded usually upon the condition that the water be supplied by meter measurement. In some cases, the man with a big political pull is able to obtain a larger water tap than another man without such affiliation. Such sizes are, of course, quite inadequate for the supply of the large

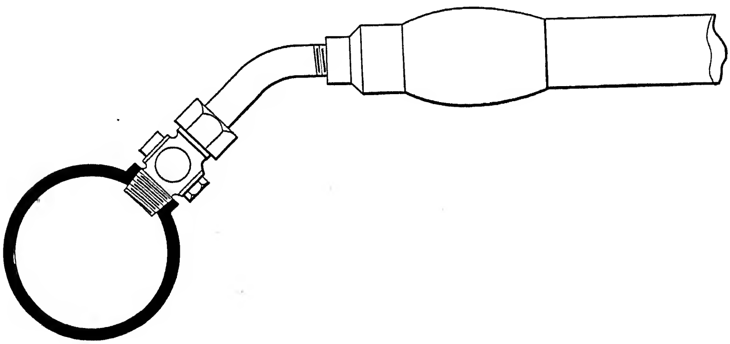


FIG. 172. Connection of Service Pipe with Water Main by Corporation Stopcock.

buildings to which reference is made in this chapter. For these the sizes of taps vary from two to four inches. Often more than one such large tap is required. Where the building extends from one street to a parallel street in the rear, it is a good plan to provide a tap in each of the streets, so that when one street main is temporarily

* See Table of Flow of Water in House Service Pipes, in Kent's Mechanical Engineer's Pocketbook, p. 578.

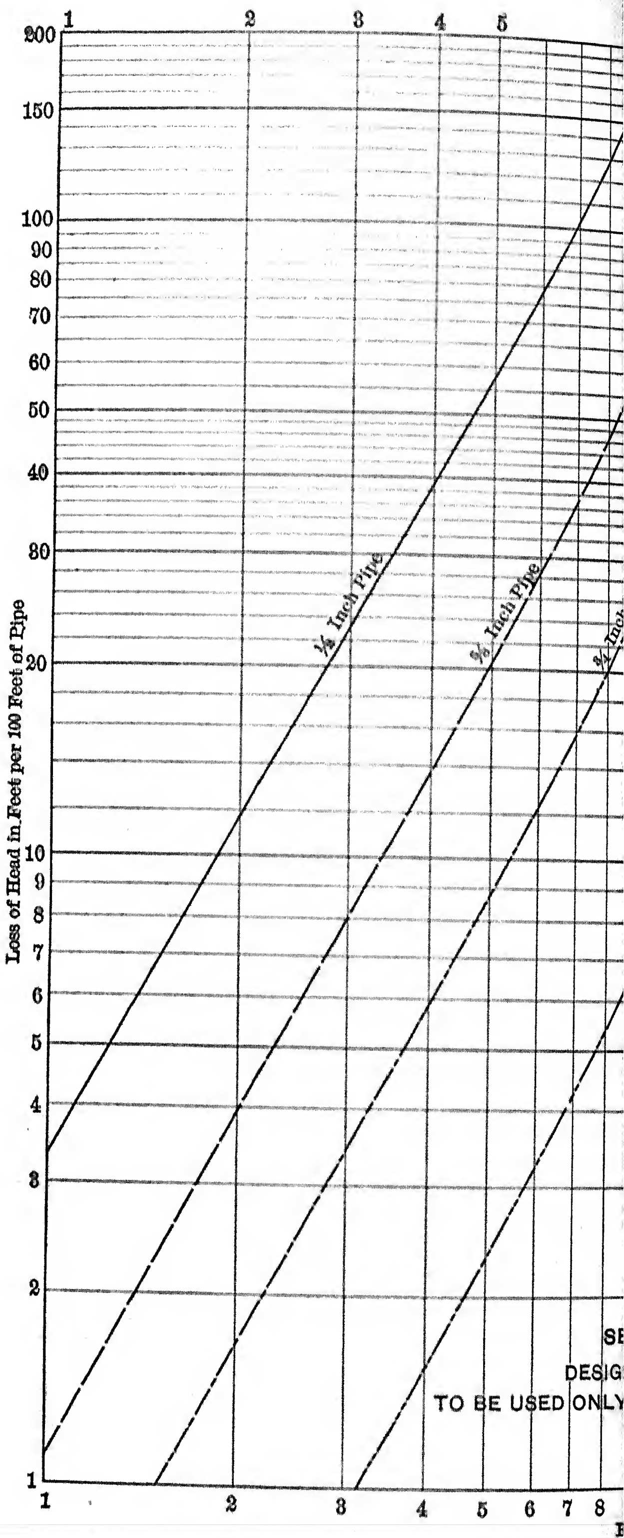
shut off for repairs or for making connections, the building shall continue to receive its supply from the other tap. It is also well to remember that at least twenty-five per cent more water may be obtained by enlarging the service pipe immediately on the house side of the street tap. (See Fig. 172.)

Examples. — For a large group of hospital buildings occupying an entire city block the writer provided for four four-inch connections, but the Water Department having refused permission for this contemplated supply, and having authorized the insertion of only four two-inch taps or branches, each service main was increased to four inches, so that four four-inch mains were brought into the pump room, thereby securing a much larger supply of water. In a hotel building having nineteen stories above the street and four stories below the street or sidewalk level, the Water Department granted the use of two two- and one four-inch branches, which were enlarged to four and six inches respectively to insure a better and more abundant supply. For another still larger hotel two four-inch and one six-inch connections were provided. For a courthouse and post-office building, occupying a floor area of 36,400 square feet (an entire city block), four two-inch taps and one four-inch connection (the latter for the boiler plant) were planned.

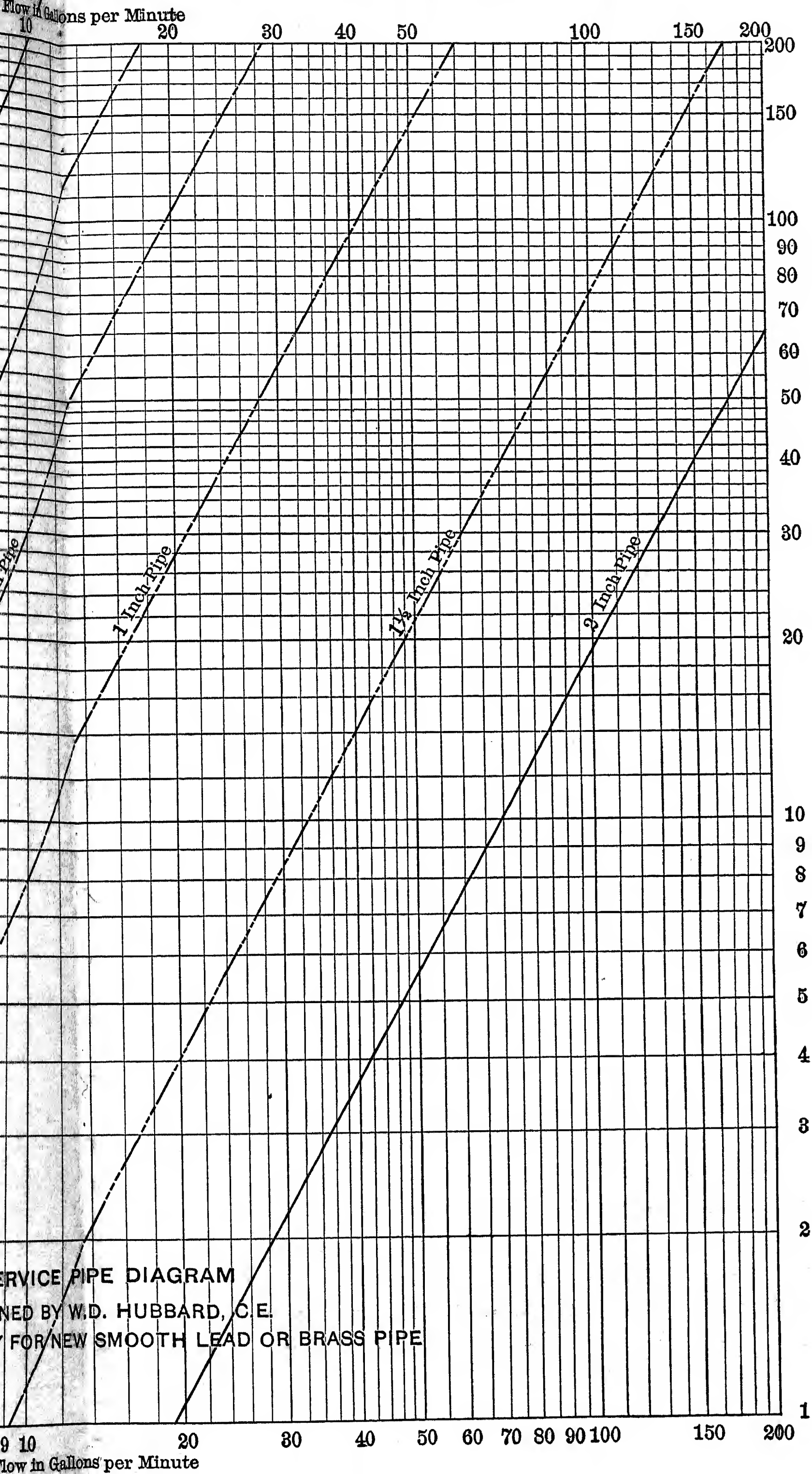
Some curious stories are related regarding the provision of, or rather the failure of providing, water taps for buildings. In one case, quoted below, an "honest" plumbing contractor failed to connect the building with the street main, while in the second instance a mistake was made by tapping the street gas main instead of the water main.

"Many of the patrons of the new —— hotel at —— left the hotel because there was no water in the house. The hotel was never connected with the water main, and since its opening water had been supplied by means of a bucket service from a near-by fire hydrant. The Water Commissioners ordered the discontinuance of this method. The hotel cost nearly a quarter million of dollars, but the man who had the plumbing contract, and who had been paid in full, had failed to connect the hotel with the water main in the street."

"An interesting story of a Connecticut plumber who by reason of his alertness and skill made a ludicrous mistake is being told by his friends. A resident who wished his house plumbing system of water supply connected



Loss of Head in Feet per 100 Feet of Pipe
½ Inch Pipe
⅜ Inch Pipe



Flow in Gallons per Minute
10
20
30
40
50
100
150
200
200
150
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
1 Inch Pipe
1½ Inch Pipe
2 Inch Pipe
ERVICE PIPE DIAGRAM
NED BY W.D. HUBBARD, C.E.
FOR NEW SMOOTH LEAD OR BRASS PIPE
9 10
20
30
40
50
60
70
80
90
100
150
200
Flow in Gallons per Minute

with the city mains had a plumber do the tapping, which he executed skillfully and quickly, and on going into the house opened the kitchen faucet, expecting to have a rush of air and then a gush of muddy water, but instead the air rushed out in an undiminished volume and filled the house with an odor far more objectionable than any city water. Looking around for the mistake, the journeyman touched a lighted match to the faucet, and immediately a bright flame shot up, lighting the house and giving the plumber considerable enlightenment at the same time, for he had tapped the gas instead of the water main."

Capacity of Filters. — Where the supply is to be filtered, the available quantity will depend primarily upon the **capacity of the filters** selected. These should therefore always be chosen generous in size and sufficient in number. The service connections should be as short as practicable, and therefore filters and surge tanks should be located in the cellar or sub-basement near the outer walls of the buildings.

Suction Tanks. — **Suction tanks** are provided for various reasons, to store a supply of filtered water available for the pumping plant, to prevent the pumps from drawing directly from the filters, which practice is not advisable, and also to prevent the pumps when working from interfering with the direct supply to the fixtures in the lowest stories of a building. **Surge tanks** may be either **open or closed tanks,** and both kinds have advantages and disadvantages. The supply, if filtered, remains uncontaminated when stored in closed tanks, and such tanks are also generally preferred as suction reservoirs for the pumping machinery. Open tanks, of course, require the supply to be controlled by several ball cocks or else by large float valves.

Delivery of Water through Taps and Services. — The **delivery of water from taps of various sizes,** under various pressures and for different lengths of service pipes, is calculated from hydraulic formulæ or else determined by means of tables or diagrams. (See Diagrams, Plate 5 in Chap. I and 17 in Chap. VIII.)

Diagram Plate 6 is reproduced, by permission, from Hubbard and Kiersted's recent book on "Water Works Management and Maintenance" (John Wiley & Sons, 1907), and gives the **discharge of service pipes for long lines of pipe** having a **very smooth interior surface** similar to that of lead pipe. This diagram has been plotted from the results given in Edmund Weston's tables. The

tables do not, however, include discharges in those cases when the corporation tap and the service pipe are not of the same diameter.

It is much to be desired that the **flow of water** through service pipes of various sizes and lengths and under different pressures and other conditions, be **determined by actual hydraulic experiments.** The results, if published, would form a very reliable guide for engineers in planning the water supply of large buildings.

Many years ago, Mr. J. Herbert Shedd, C. E., of Providence, R. I., plotted a diagram to be used in determining the sizes of service pipe and tap connections.*

In the November, 1905, issue of *Cassier's Magazine* the author published an article on "The Discharge of Water through Street Taps and Service Pipes," accompanied by several diagrams representing the results of a number of long and tedious calculations, which diagrams are reproduced in Plates 7, 8 and 9.

The discharges of taps and service pipes, when of the same diameter, were calculated for him from Prony's formula,

$$G = \left(\frac{(3d)^5 \times H}{L}\right)^{\frac{1}{2}} \times 1.20032,$$

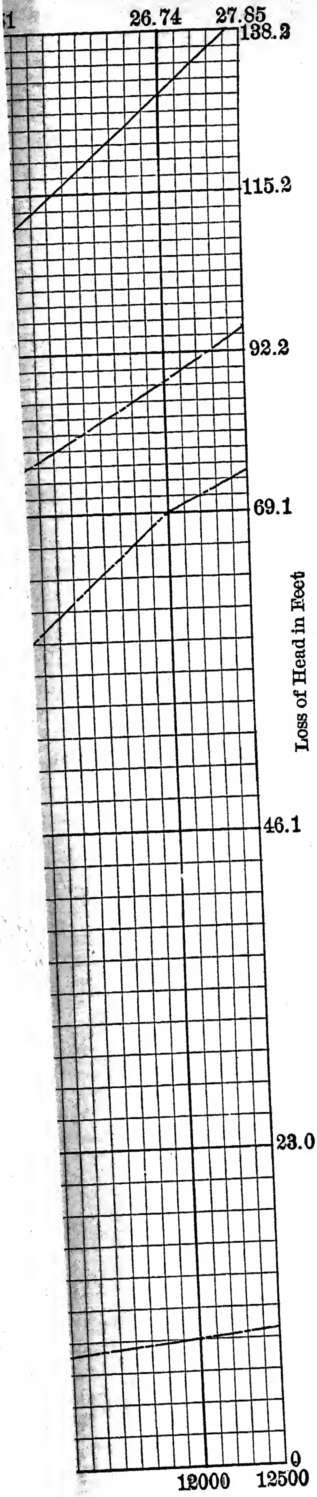
in which G = U. S. gallons per minute,
d = diameter of pipe in inches,
L = length of pipe in yards,
H = head of water in feet.

The friction loss due to the tap, if of smaller size than the service, was computed from Merriman's formula,

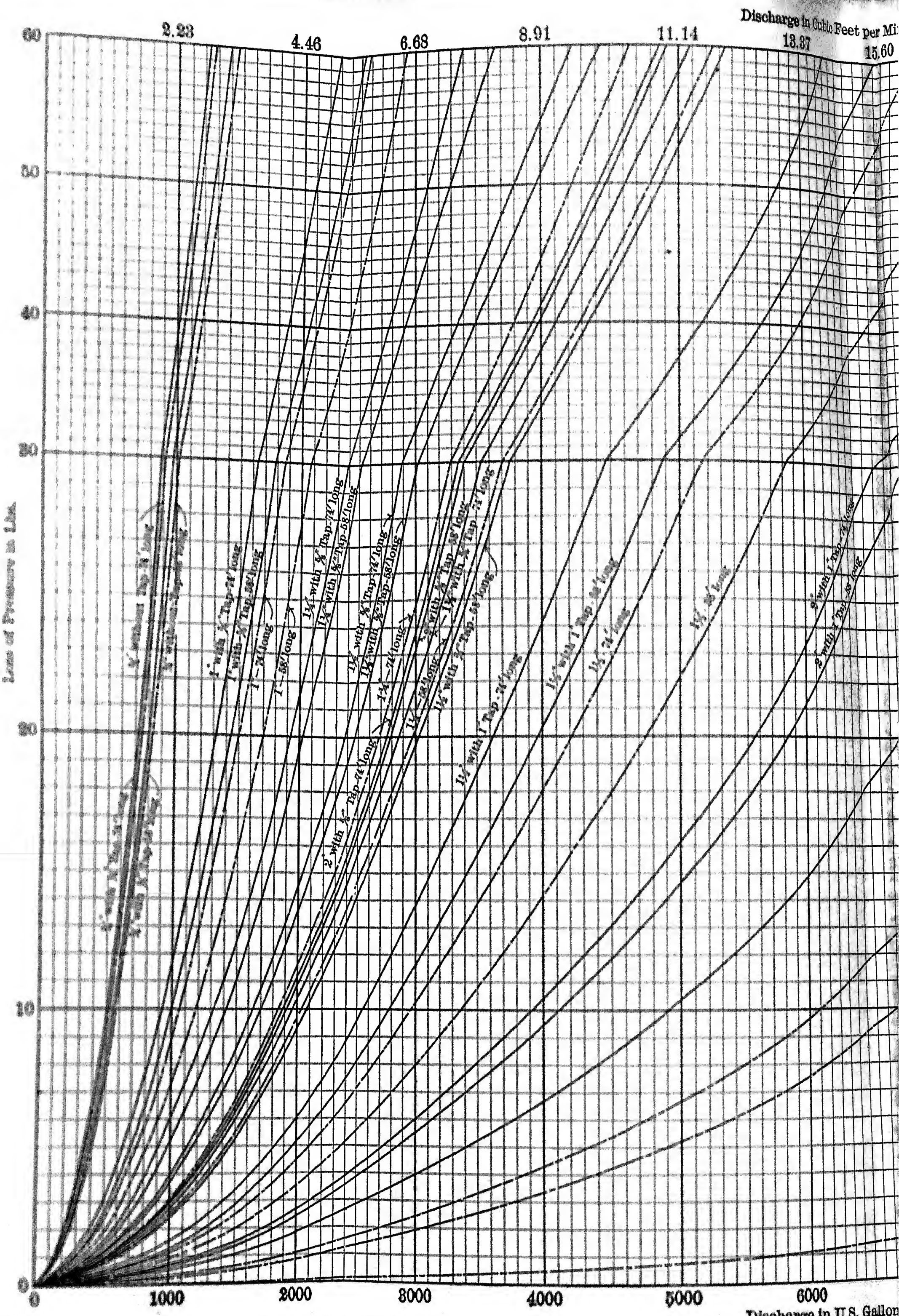
$$H_1 = f\left(\frac{L \times v^2}{d \times 2g}\right),$$

in which H_1 = loss of head in friction in feet,
L = length of pipe in feet,
d = diameter of pipe in feet,
v = velocity of flow in feet per second,
g = 32.16,
f = friction coefficient, varying from 0.05 to 0.01 and assumed as 0.024.

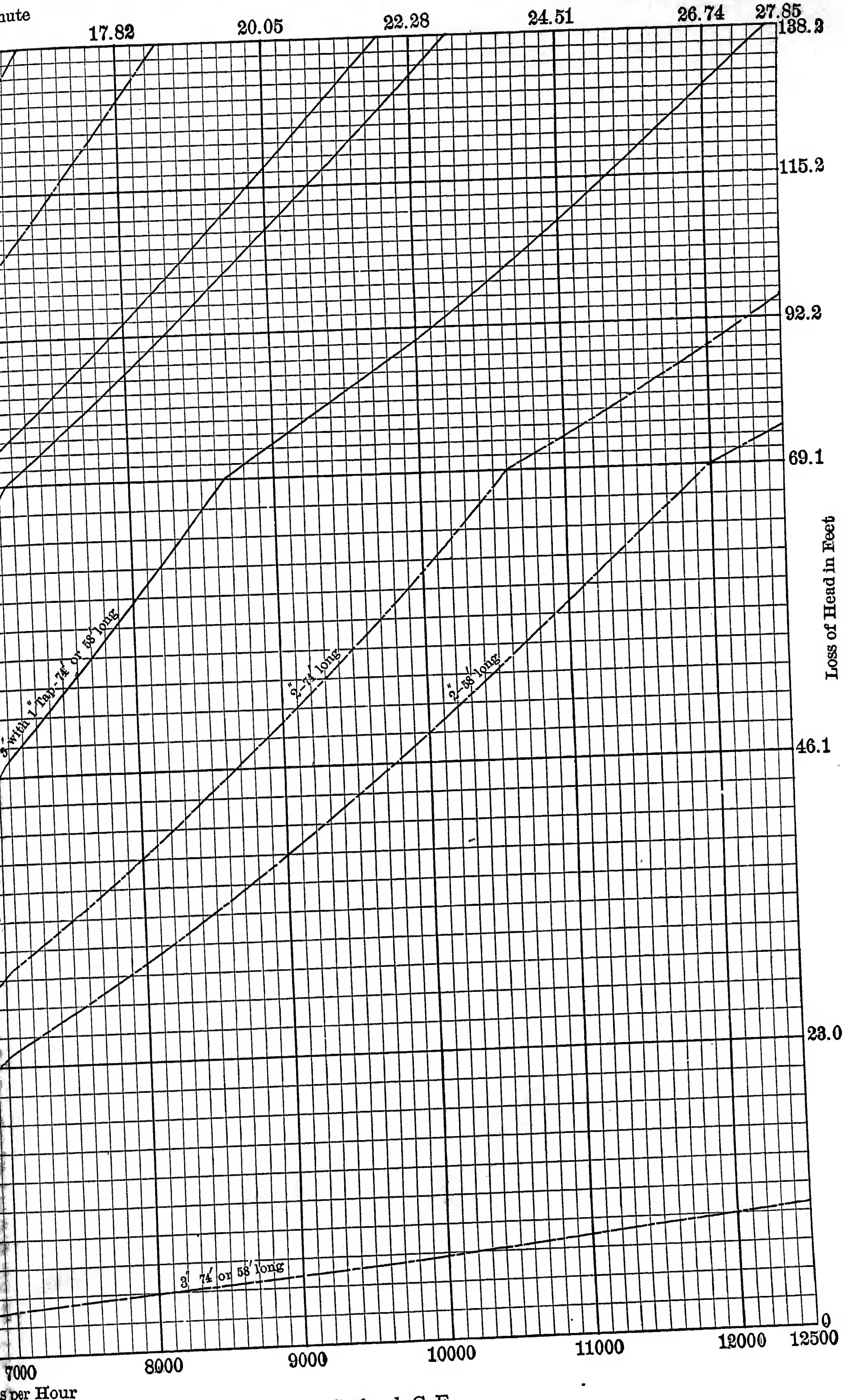
* See *Engineering Record* of November 7, 1891.



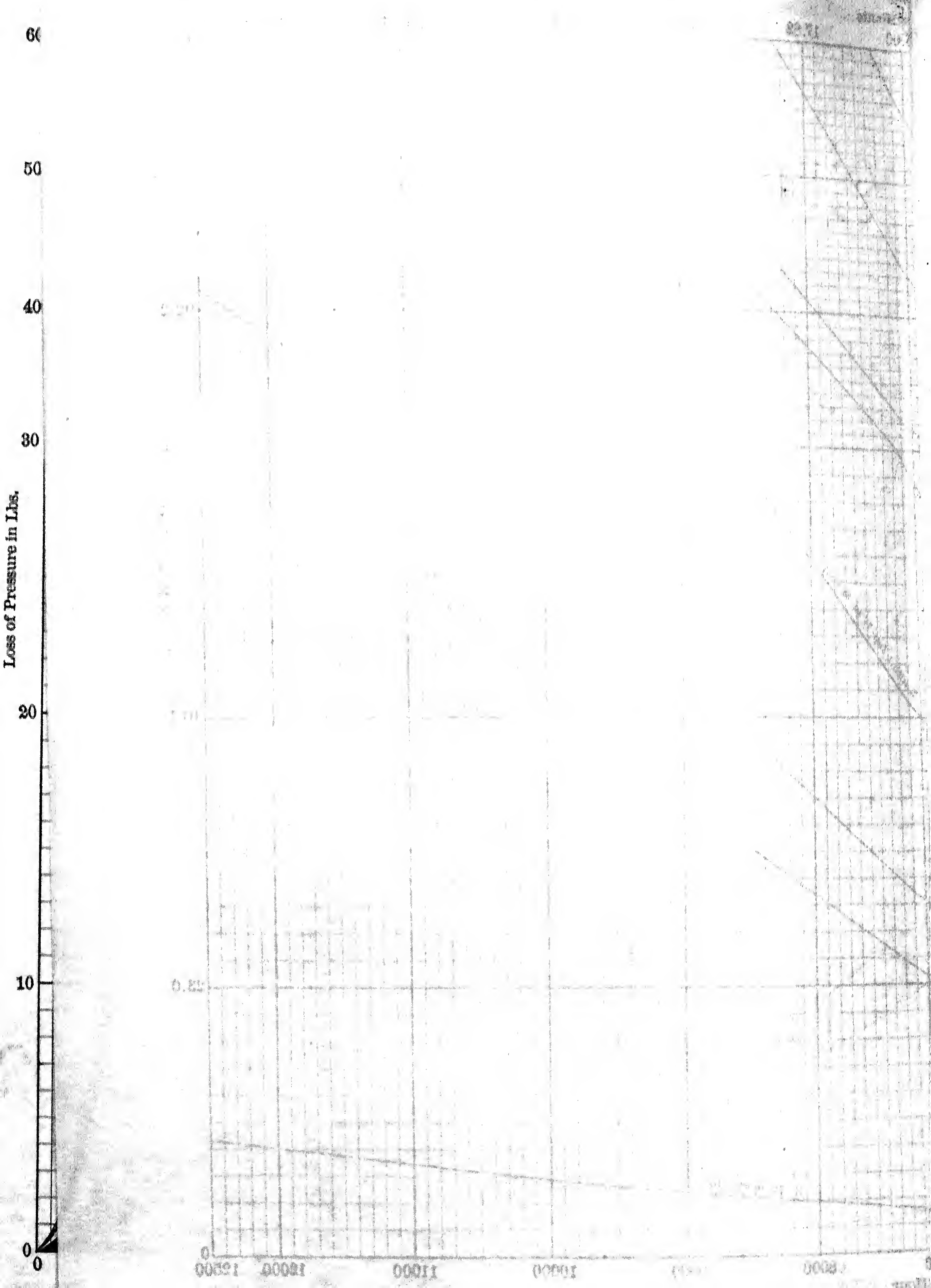
26.74
27.85
138.2
115.2
92.2
69.1
46.1
23.0
0
Loss of Head in Feet
12000
12500

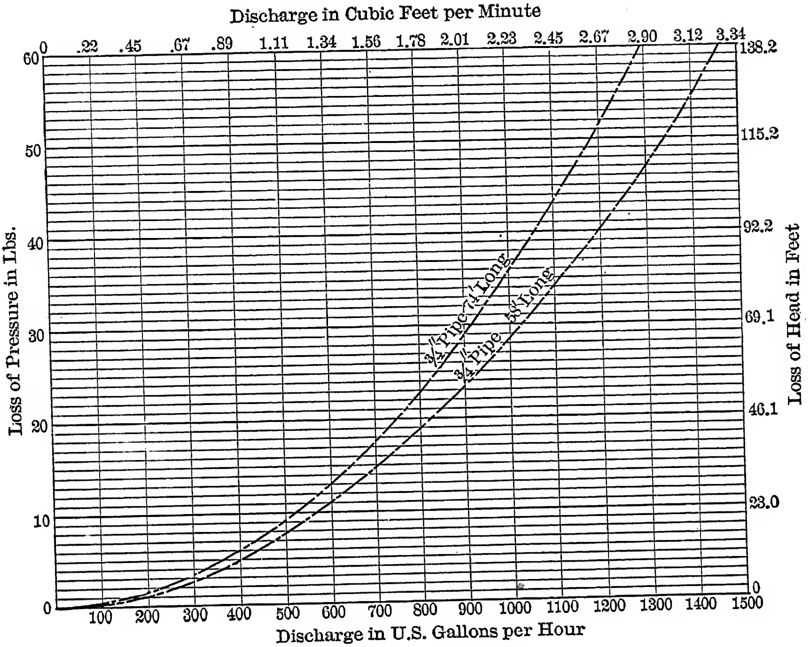


Discharge in Cubic Feet per Mi
2.23
4.46
6.68
8.91
11.14
13.37
15.60
Loss of Pressure in Lbs.
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
6000
Discharge in U.S. Gallon
1" with ¾" Tap-74' long
1" with ¾" Tap-58' long
1"-74' long
1"-58' long
1¼" with ⅝" Tap-74' long
1¼" with ⅝" Tap-58' long
1¼"-74' long
1¼"-58' long
1½" with 1" Tap-74' long
1½"-58' long
2" with 1" Tap-74' long
2" with 1" Tap-58' long
2" with ⅝" Tap-74' long



nute
17.82
20.05
22.28
24.51
26.74
27.85
138.2
115.2
92.2
69.1
46.1
23.0
0
Loss of Head in Feet
3" with 1" Tap-74' or 58' long
2"-74' long
2"-58' long
3" 74' or 58' long
7000
8000
9000
10000
11000
12000
12500
s per Hour


Loss of Pressure in Lbs.
60
50
40
30
20
10
0
0



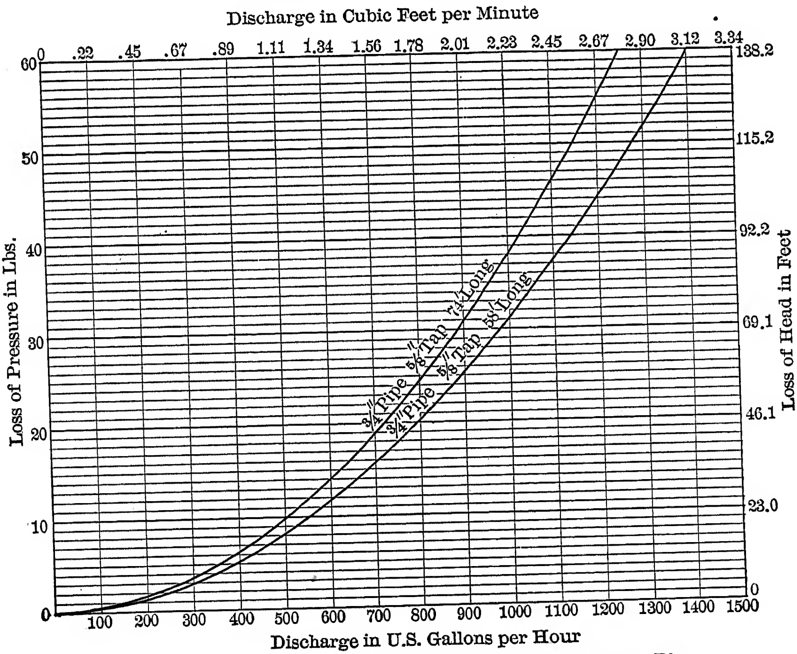
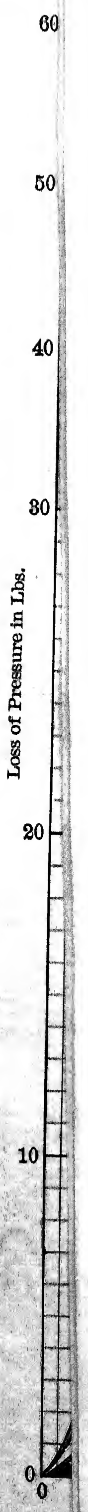


DIAGRAM 8. Discharge of Three-quarters Inch Service Pipe.



Diagrams. — The results of the calculations were plotted in the **diagrams 7 and 8 for two lengths of service pipes,** viz., 74 feet and 58 feet. The third diagram, Plate 9, is based upon the fact that the discharge for different lengths of pipe varies inversely as the square root of the lengths, and is useful in finding discharges of service pipes of other than the above lengths.

The **curves of discharge** given in these diagrams exhibit clearly the advantage secured by increasing the diameter of the service pipe over and above the size of the tap.

There is but one slight disadvantage in using large-sized service pipes where a building is supplied directly from street pressure, and that is that more water remains dead in the pipes while no water is drawn, so that it is necessary to withdraw and waste a larger amount to get a supply of fresh water from the street main, where the water is constantly circulating.

Inasmuch as the curves for three-quarters-inch and one-inch service pipes in Diagram Plate 7 come rather close together, and in order to enable the reading of the discharges with greater clearness, I prepared Plate 8 for three-quarters-inch pipes and $\frac{5}{8}$ inch taps, the curves in both diagrams being computed and plotted in the same manner as in the larger diagram.

Plate 23 in the Appendix gives a useful graphical representation of the equivalents of pounds pressure and pressure head in feet, and of discharges in cubic feet per minute and in United States gallons per hour.

Tables. — Table No. IX was published some years ago by William Rotch, Chief Engineer of the Fall River Waterworks, and gives the **quantity of water, in gallons per minute, delivered by service pipes** of various sizes from one-half inch to four inches, under various pressures. H represents the head of water and L the length of pipe, in feet.

Table X was calculated by me from data given in the "Handbuch der Ingenieur-Wissenschaften," based upon the Kutter formula with a coefficient of roughness corresponding to old pipes.

The amount of water delivered by **old pipes with rough interior** surface and full of incrustations, according to this table, is very much smaller than that given by the usual diagrams or tables which suppose the pipes to be clean and new.

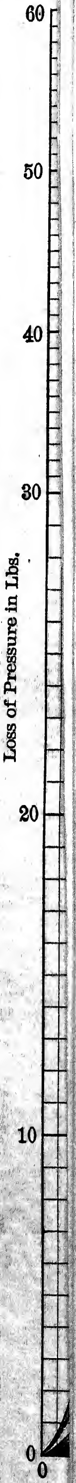

Loss of Pressure in Lbs.
60
50
40
30
20
10
0
0

TABLE IX.

Diam. of Pipe in Inches.	H 10 L	H=9 L	H=8 L	H=7 L	H=6 L	H=5 L	H=4 L	H=3 L	H=2 L	H=1¾ L	H=1½ L
½	19.8	18.7	17.7	16.5	15.3	14.0	12.5	10.8	8.8	8.3	7.7
⅝	34.5	32.7	30.1	28.9	20.5	24.4	21.8	18.9	15.4	14.4	13.4
¾	54.4	51.7	48.7	45.6	42.2	38.5	34.4	29.8	24.3	22.8	21.1
1	111.8	106	100	93.5	86.6	79	70.7	61.2	50	46.8	43.2
1¼	195.2	185.2	174.6	163.3	151.2	138	123.4	106.9	87.3	81.6	75.6
1½	308	292.1	275.4	257.6	238.5	217.7	194.8	168.7	137.7	128.8	119.3
2	632.2	599.7	566.4	538.9	488.1	447	399.8	346.3	282.7	264.4	248.8
2½	1104	1048	987.8	924	855.4	780.9	698.5	604.9	493.9	482	427.7
3	1745	1631	1560	1460	1351	1234	1103	955.5	780.2	728.8	674.8
4	3581	3397	3203	2996	2774	2532	2265	1962	1602	1496	1385

Diam. of Pipe in Inches.	H=1¼ L	H=L	H=¾ L	H=½ L	H=⅓ L	H=¼ L	H=⅕ L	H=⅙ L	H=1/7 L	H=⅛ L	H=1/9 L	H=1/10 L
½	7.0	6.3	5.4	4.4	3.6	3.1	2.8	2.6	2.4	2.2	2.1	2.0
⅝	12.2	10.9	9.5	7.7	6.3	5.5	4.8	4.4	4.1	3.9	3.6	3.5
¾	19.3	17.2	14.9	12.2	9.9	8.6	7.7	7.0	6.5	6.1	5.7	5.4
1	39.5	35.3	30.1	25	20.4	17.7	15.8	14.4	13.4	12.5	11.8	11.2
1¼	69	61.7	53.5	43.7	35.6	30.9	27.6	25.2	23.3	21.8	20.6	19.5
1½	108.9	97.4	84.3	68.7	56.2	48.7	43.9	39.8	36.8	34.4	32.5	30.8
2	223.5	199.9	173.1	141.4	115.4	100	89.4	81.6	75.6	70.7	66.6	63.2
2½	390.4	349.2	302.4	246.9	201.6	174.6	156.2	142.6	132.0	123.6	116.4	110.4
3	615.9	555.5	477.1	390.1	317.6	275.8	246.7	225.2	208.5	195.1	183.9	174.5
4	1264	1133	979.3	800.8	653.8	566.2	506.5	463.2	428.0	399.9	377.5	358.1

Loss of Pressure in Lbs.

0 10 20 30 40 50 60

TABLE X.

Giving Discharges of Old Water Pipes with Rough Interior Surfaces (Coefficient of Roughness in Ganguillet-Kutter Formula taken as $b = 0.35$).

After Table in Handbuch der Ingenieur-Wissenschaften, Part III, "Wasserbau," 4th Edition, 1904.				Amount in Gallons per Minute.			Calculations in this Table, except 5th column (taken from "Handbuch"), made by Wm. Paul Gerhard, C.E., 1908.			
Diameter of Pipe in Inches and Centimeters.		$J = \frac{1}{4}$	$J = \frac{1}{10}$	$J = \frac{1}{25}$	$J = \frac{1}{50}$	$J = \frac{1}{100}$	$J = \frac{1}{150}$	$J = \frac{1}{200}$	$J = \frac{1}{250}$	$J = \frac{1}{400}$
$\frac{3}{8}''$	1 cm.	0.396	0.251	0.159	0.112	0.079	0.065	0.056	0.050	0.040
$\frac{5}{8}''$	1.5	1.268	0.802	0.507	0.359	0.254	0.207	0.179	0.160	0.127
$\frac{3}{4}''$	2	2.932	1.855	1.173	0.829	0.587	0.479	0.415	0.371	0.293
$1''$	2.5	5.706	3.609	2.282	1.614	1.141	0.932	0.807	0.719	0.571
$1\frac{3}{16}''$	3	9.510	6.015	3.804	2.670	1.902	1.553	1.345	1.203	0.951
$1\frac{5}{8}''$	4	22.190	14.034	8.876	6.276	4.438	3.623	3.138	2.807	2.219
$2''$	5	42.795	27.066	17.118	12.104	8.559	6.988	6.052	5.413	4.280
$3\frac{3}{16}''$	8	162.463	102.751	64.985	45.951	32.493	26.527	22.983	20.550	16.246
$3\frac{15}{16}''$	10	305.905	193.473	122.362	86.522	61.181	49.948	43.262	38.695	30.591
$6''$	15	966.850	611.762	386.740	273.464	193.370	157.890	136.732	122.307	96.685

For any other value of J, called J_1, take figures of 5th vertical column (for $J = \frac{1}{100}$) and multiply it with $10\sqrt{J_1}$.

$$J = \frac{\text{Loss of Head in Feet}}{\text{Length of Pipe in Feet}}.$$

Table No. XI gives the **discharge in United States gallons per minute,** and in 24 hours, **through different sized orifices** (not pipes), under different heads. The table is taken from the thirty-first Annual Report of the Dayton, Ohio, waterworks.

TABLE XI.

Showing Number of Gallons of Water Discharged through Orifices of Different Size, with Different Heads of Water, in One Minute and in 24 Hours.

Diameter of Aperture.		$\frac{1}{32}''$		$\frac{1}{16}''$		$\frac{1}{8}''$		$\frac{1}{4}''$		$\frac{3}{8}''$		$\frac{1}{2}''$	
		United States Gallons Discharged. *a. In One Minute.* *b. In 24 Hours.*											
Head of Water in Feet.	Lbs. Press. per Sq. In.	a	b	a	b	a	b	a	b	a	b	a	b
20	8.8	.085	122	.34	490	1.36	1958	5.47	7877	12.31	17726	21.88	31507
40	17.6	.12	173	.48	691	1.93	2379	7.73	11131	17.40	25056	30.94	44553
60	26.4	.148	213	.59	850	2.36	3398	9.47	13636	21.31	31686	37.89	54561
80	35.2	.17	245	.68	979	2.73	3931	10.94	15753	24.62	35452	43.76	63014
100	44.	.191	275	.76	1094	3.05	4392	12.24	17425	27.54	39657	48.95	70488
120	52.8	.21	302	.83	1195	3.35	4824	13.04	19296	30.15	43416	53.6	77184
140	61.6	.227	327	.905	1303	3.61	5198	14.48	20851	32.58	46715	57.91	83390
160	70.4	.242	348	.967	1392	3.86	5558	15.47	22276	34.81	50126	61.88	89107
180	79.2	.257	370	1.02	1469	4.1	5904	16.38	23587	36.93	53179	65.65	94536
200	88.	.271	390	1.08	1555	4.32	6221	17.30	24912	38.94	56073	69.23	99591

TABLE XI (Continued).

Diameter of Aperture.		5/8″		3/4″		7/8″		1″		1¼″		1½″	
		United States Gallons Discharged. *a. In One Minute.* *b. In 24 Hours.*											
Head of Water in Feet.	Lbs. Press. per Sq. In.	a	b	a	b	a	b	a	b	a	b	a	b
20	8.8	44.1	49104	49.2	70818	67.	96480	87.5	126000	136.7	196848	196.9	283536
40	17.6	48.3	69552	69.6	100224	94.7	136368	123.7	178128	193.3	276352	278.4	400896
60	26.4	59.2	85248	87.25	125640	116	167040	151.5	218160	236.8	340992	341.5	491760
80	35.2	68.3	98352	98.4	141696	134	192960	175	252000	273.5	393840	393.9	567216
100	44.	76.4	110016	110.1	158544	150	215856	195.8	281952	305.8	440352	440.6	634464
120	52.8	83.7	120528	120.6	173664	164.1	236304	214.4	308736	335.	482400	482.4	694656
140	61.6	90.49	130305	130.3	187632	177.3	255312	231.6	333504	361.9	521136	521.2	750528
160	70.4	96.69	139233	139.2	200448	189.5	272880	247.5	356400	386.7	556848	556.9	801936
180	79.2	102.58	147715	147.7	212688	201	289440	262.6	378144	410.3	590832	590.8	850752
200	88.	108.17	155764	155.7	224208	212	305280	276.9	398736	432.6	622944	623.	897120

Table No. XII gives the **discharge** in gallons per hour **of street sprinklers and fountains.** It was computed by J. Nelson Tubbs, Chief Engineer of the Rochester, N. Y., Waterworks from formula

$$Q = 37.548 \frac{\sqrt{H \times D^5}}{\sqrt{L + 35.47 \dfrac{D^5}{M^2 d^4}}},$$

in which Q = cubic feet per second,
H = head,
D = diameter of service,
d = diameter of nozzle,
L = length of service,
M = coefficient of discharge, taken at 0.90.

The table is calculated for a head of 90 feet.

TABLE XII.

Size of Service.	Size of Jet.	Length of Service or Hose.		
		100 ft.	150 ft.	200 ft.
		U. S. Gallons per Minute.		
½ inch	¼ inch	299.40	253.92	224.48
⅝ "	"	420.66	372.50	337.69
¾ "	"	522.27	485.87	456.16
1 "	"	536.43	528.04	518.71
½ "	⅛ "	142.74	136.83	131.61
⅝ "	"	151.53	148.99	146.37
¾ "	"	155.11	153.95	153.03
1 "	"	156.76	156.50	156.21
½ "	1/16 "	39.06	38.93	38.86
⅝ "	"	39.23	39.18	39.09
¾ "	"	39.29	39.27	39.25
½ "	1/32 "	11.02	11.02	11.02
⅝ "	"	11.02	11.02	11.02

Table No. XIII gives the **height and discharge volume of jets or fire streams** in feet under different heads and through nozzles of various sizes, and is condensed by me from the elaborate tables prepared by John R. Freeman, C. E.

TABLE XIII.

Table of Discharge of Fire Nozzles under Different Pressures.

(Condensed from John R. Freeman's Tables, 1889.)

N. Pr. Nozzle Pressure.	¾″ smooth nozzle and ⅞″ ring nozzle.				⅞″ smooth nozzle and 1″ ring nozzle.				1″ smooth nozzle.				1⅛″ smooth nozzle. (This is size preferred for outside use.)				1¼″ smooth nozzle. (Size adapted for serious fires, where water is ample.)			
	G.	H.	D.	H.Pr.	G.	H.	D.	H.Pr.	G.	H.	D.	H.Pr.	G.	H.	D.	H.Pr.	G.	H.	D.	H.Pr.
20	73	33	29	22	100	34	33	23	132	35	37	25	168	36	38	28	209	37	40	32
25	82	41	33	27	112	42	38	29	147	43	42	31	188	44	44	35	234	46	47	40
30	90	48	37	32	123	49	42	34	161	51	47	37	206	52	50	42	256	53	54	49
40	104	60	44	43	142	62	49	46	186	64	55	50	238	65	59	56	296	67	63	65
50	116	67	50	54	159	71	55	57	208	73	61	62	266	75	66	70	331	77	70	81
60	127	72	54	65	174	77	61	69	228	79	67	75	291	83	72	84	363	85	76	97
80	147	79	62	86	201	85	70	91	263	89	76	100	336	92	81	112	419	95	85	129
100	164	83	68	108	224	90	76	114	295	96	83	125	376	99	89	140	468	101	93	162

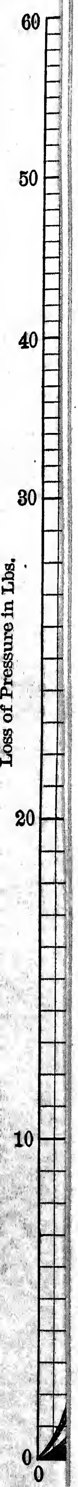
80 lbs. at hydrant is considered best fire pressure.
100 lbs. at hydrant should not be exceeded, except for very high buildings.
20 and 25 lbs. at nozzle characterized as feeble stream.
30, 40, 50 and 60 lbs. at nozzle characterized as ordinary fire stream.
80 and 100 lbs. at nozzle characterized as unusually high pressure.

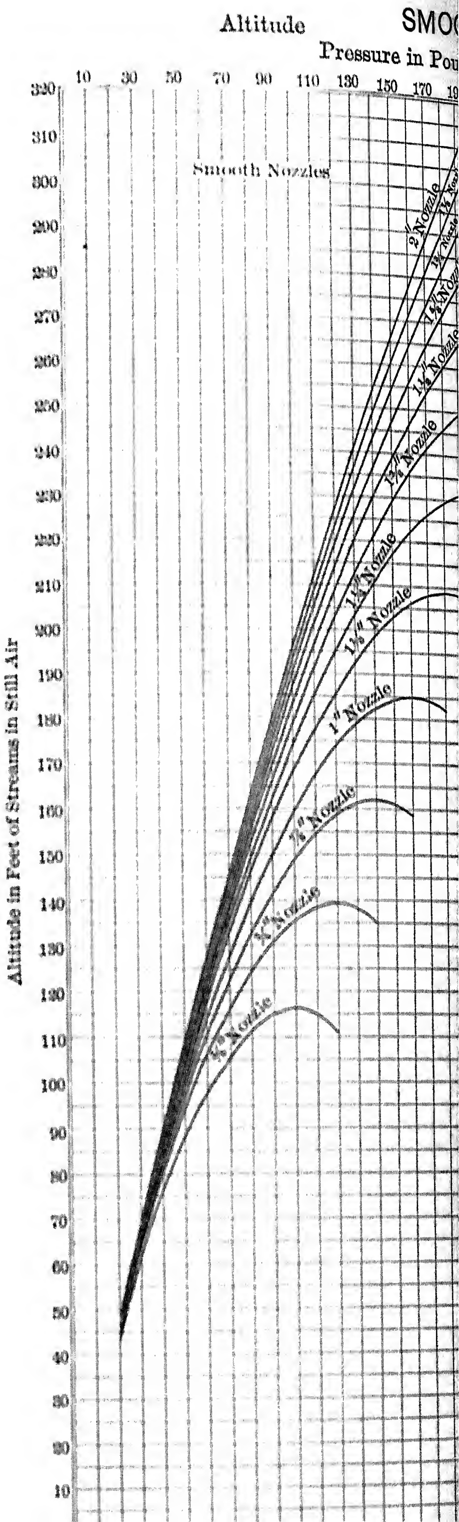
20 lbs. at nozzle characterized as feeble stream.
30 " " " " fair fire "
40 " " " " good " "
50 and 60 " " " excellent.
80 and 100 " " " unusually strong stream.

N.Pr. = Pressure at base of nozzle.
H.Pr. = Hydrant pressure, with 100 ft. best quality rubber-lined hose.
H = Maximum limit of height as good effective fire stream with moderate wind.
D = Maximum limit of distance as a good effective fire stream with moderate wind.

H is 10% higher for a fair fire stream.
D is 12% greater " " " "

G. = U. S. Gallons discharged per minute.

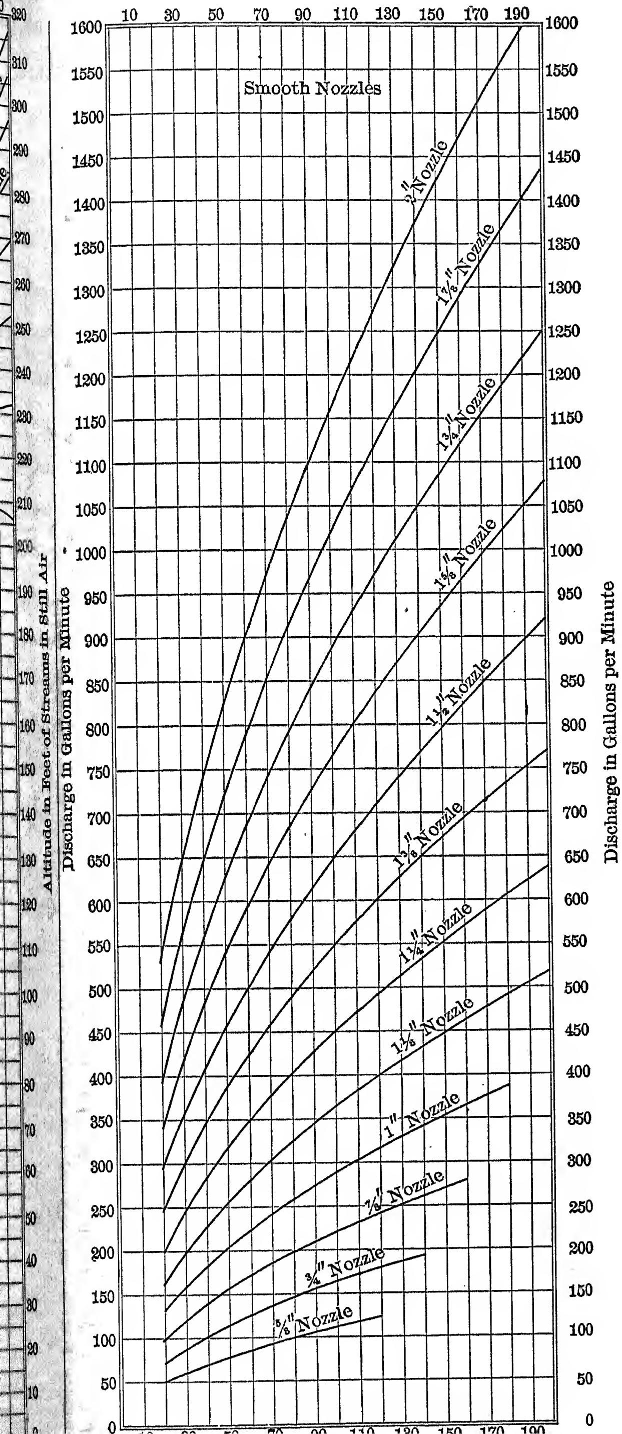

Loss of Pressure in Lbs.
60
50
40
30
20
10
0
0


Altitude
SMOO
Pressure in Pou
Smooth Nozzles
Altitude in Feet of Streams in Still Air
2" Nozzle
1¾" Nozzle
1⅝" Nozzle
1½" Nozzle
1⅜" Nozzle
1¼" Nozzle
1⅛" Nozzle
1" Nozzle
⅞" Nozzle
¾" Nozzle
⅝" Nozzle

OTH NOZZLES

Gallons per Min.

nds per Square Inch at Nozzle




60
50
40
30
20
10
0
0

Diagram Plate 10 exhibits the relation between pressure, altitude and discharge of fire nozzles in graphical form, the curves of discharge being plotted by John W. Hill, C. E., of Cincinnati.

Still another convenient exhibit of the flow of water in small pipes is given in Table XIV, taken from Collet's work on "Water Softening and Purification," the British or Imperial gallons being changed by me to United States gallons.

The curves in Diagram Plate 11 were plotted for me to find at a glance the required theoretical horse power of small pumps, where the pumping head and the amount of water to be pumped are given.

Quality of Water.— The **quality of the water** delivered by the street mains is often far from satisfactory from a sanitary point of view. To overcome this fault, it has become a common practice to filter the entire supply as it enters the building through the service pipe, except possibly such connections as outside sill cocks, hose bibs for window washing, etc. Filtration is nearly always accomplished by so-called **mechanical** or **closed pressure filters;** the open or gravity filters, which are used in waterworks systems, are not so well adapted for use in buildings.

Water Filtration. —**Mechanical filters** consist of either wrought or cast iron cylinders, set up singly or in batteries of two. (See Fig. 171, Chapter V.) They are filled with sand, charcoal, or some other filtering medium, and sometimes an alum-feeding attachment is added, which is used at times when the water is more than usually turbid or "roily." The process of filtration in such apparatus is largely a straining process, which clarifies the water without, however, rendering it germ-free. It is nevertheless worth considering, because it makes the water better adapted for use in the steam boilers, prevents the usual disagreeable deposit of mud in the house-tanks and in flushing cisterns, and keeps the supply pipes clean, thus, in a measure, preventing the loss of pressure in them.

The continuous good working of a filter depends upon the frequency with which its periodic cleansing and washing is attended to. This washing process is somewhat tedious and slow, and requires a large volume of water to clean the filter beds thoroughly. Unless the washing of filters is faithfully and regularly performed, the filter batteries soon loose their efficiency. A pressure gauge attached to the water main before it enters the filter, together with a second

TABLE XIV.

Table of Flow of Water in U. S. Gallons per Minute through Straight, Clean Pipes.

(After Collet.)

Diameter of Pipe in Inches.	Head of Water Divided by Length of Pipe (in feet).								
	$\frac{1}{100}$	$\frac{1}{50}$	$\frac{1}{25}$	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{5}{10}$	$\frac{8}{10}$	$\frac{1}{1}$
$\frac{1}{16}''$	...	...	...	.029	.043	.055	.072	.092	.103
$\frac{1}{8}''$	...	...	...	.067	.090	.107	.149	.190	.216
$\frac{3}{16}''$	...	...	...	.17	.25	.31	.41	.53	.60
$\frac{1}{4}''$	...	...	...	.37	.53	.62	.86	1.10	1.25
$\frac{3}{8}''$	.26	.40	.60	1.00	1.4	1.8	2.4	3.1	3.5
$\frac{1}{2}''$	.55	.84	1.20	2.2	3.0	3.7	4.9	6.4	7.2
$\frac{3}{4}''$	1.60	2.38	3.5	5.9	8.5	10.7	14.0	18.0	20.3
1″	3.35	4.98	7.3	12.0	17.8	22.1	28.8	37.2	42.0
$1\frac{1}{4}''$	5.95	8.83	13.0	21.6	31.2	38.4	50.4	64.8	73.2
$1\frac{1}{2}''$	9.52	14.10	20.6	33.6	49.2	61.2	80.4	103.2	116.4
2″	19.9	28.8	43.2	70.8	103.2	127.2	168.0	214.8	242.4
3″	55.2	82.8	121.2	199.2	288.0	357.6	468.0	600.0	674.4

NOTE: If the diameter of a pipe be doubled, nearly 5.8 the quantity can be passed.

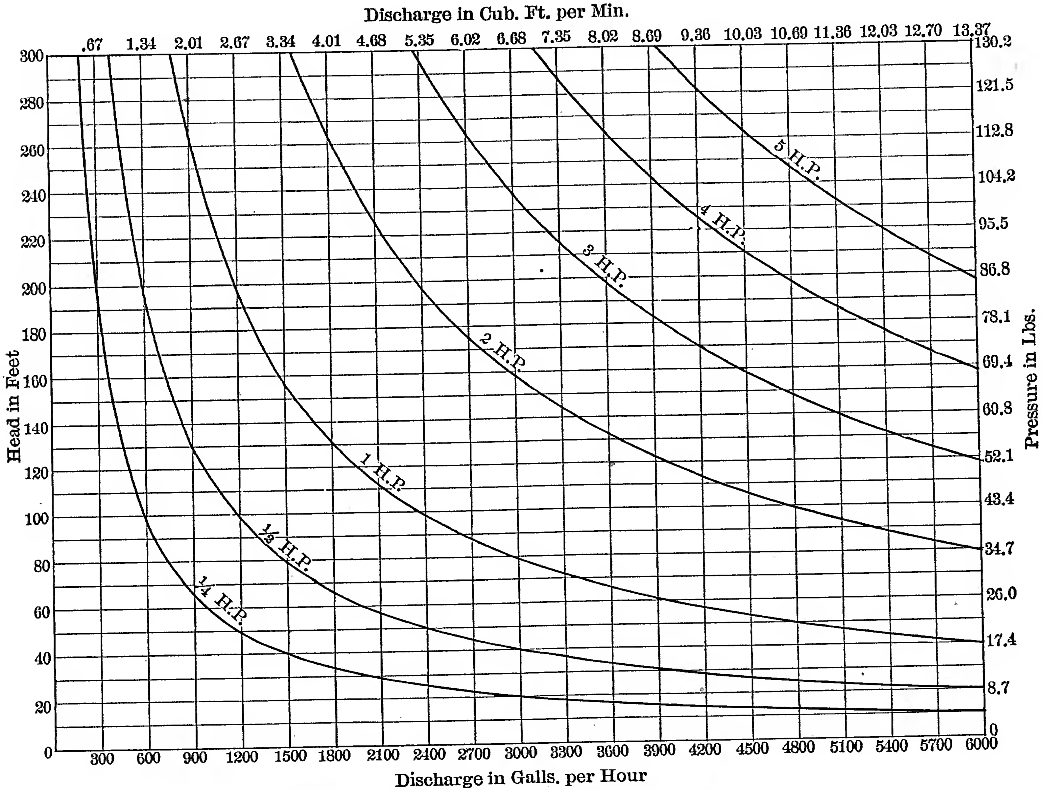


DIAGRAM II. Theoretical Horse-Power required for Pumps.


60
50
40
30
20
10
0
0

gauge on the main carrying the filtered water, will at once indicate, by the loss of pressure, whether or not the filter requires washing.

For the **drinking-water supply,** which is comparatively small in volume, the best practice calls for special **germ-proof filters,** such as filters in candle form, made of infusorial earth, like the Berkefeld filter and others, or else natural stone filters are used, usually in connection with a plant for cooling the water. These, too, have to be frequently cleaned and sterilized from time to time, and it is well to bear constantly in mind that a so-called "germ-proof" filter does not really exist.

It would seem at first glance desirable that a municipality should provide filtration works rather than that it be left to the individual water consumers to filter their supply. Unusual precautions must be observed, however, where the entire supply for a city is filtered, to keep the water pure *after* filtration. To protect the filtered water against contamination, it must be stored in covered storage reservoirs, which involve quite an expense in construction. In open storage reservoirs, the filtered supply would nearly always become exposed to further contamination, and where the water mains in the streets are old and full of deposits of mud, clay and iron rust, the filtered supply soon becomes turbid and dirty, and as delivered into buildings it would, in most cases, necessarily have to be *refiltered* before being suitable for use. Hence in some instances it is advisable to provide two supplies, one for potable water, the other for such uses of water where filtration seems to be unnecessary. Instances may in this way occur when it would be more economical not to filter the entire supply for a city, but to leave the purification of a part of it to the individual owners of buildings. There seems to be no reason why this should not even be regulated by law. If health regulations can compel a landlord to abolish cesspools and wells, to provide soil and vent pipes and traps, to install water-closets with cistern flush, what is to prevent their going a step further and requiring the drinking-water supply to be filtered?